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CYCLONE MEMOIRS,

No. V.

ACCOUNT OF THREE CYCLONES

IN THE

BAY OF BENGAL AND ARABIAN SEA

DURING THE

MONTH OF NOVEMBER 1891,

VIZ., THE PORT BLAIR CYCLONE OF 1st TO 7th, THE MINICOY
CYCLONE OF 1st TO 3rd AND THE CYCLONE OF 19th TO 23rd.

BY

J. ELIOT, M. A.,
METEOROLOGICAL REPORTER TO THE GOVERNMENT OF INDIA.

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CHAPTER I.

Introduction.

The present part of the Bay of Bengal and Arabian Sea Cyclone Memoirs gives an account of three cyclonic storms which visited the Indian area in November 1891. The meteorology for some time previous to their occurrence was characterized by very marked abnormal features, which modified and controlled to a large extent the character and paths of the storms. The three storms were hence marked by several peculiar features, whilst one of them (the first storm) was of very great intensity. It hence appears to be desirable to give a full account of this group of storms.

Brief statement of the first storm.

The first storm in order of time of formation is that which is described in Chapter IV, and is, for the sake of convenience, called the Port Blair cyclone. It originated in the Gulf of Siam, probably on the 29th and 30th October, under conditions which are at present, in the absence of information, unknown. It advanced in a west-north-west direction across the Gulf of Siam. The centre struck the east coast of the Malayan Peninsula at the port of Chaiya (in Lower Siam), which was almost completely wrecked by the storm with great loss of life. The storm passed across the comparatively low ground to the south of the Isthmus of Krah and the Andaman Sea at an average rate of nearly 19 miles per hour on the 1st November.

The centre passed over Port Blair on the early morning of the 2nd. The hurricane winds caused great destruction of life and property in a belt of country about 50 miles wide in the South Andaman Island. The S.S. *Enterprise*, which was lying in Port Blair Harbour, went down during the storm, the whole of the crew being lost with the exception of six lascars. The storm advanced in the same west-north-west direction in the Bay on the 2nd and began to recurve on the 3rd. It was advancing northwards on the 4th off the coast of the Circars, and on the 5th continued to recurve to east. The centre was about 50 miles east of Gopalpur at about 4 A.M. of the 5th, and 10 or 12 miles east of Puri about 8-30 A.M. The centre passed over the False Point Lighthouse between 4-15 P.M. and 4-45 P.M., and was then marching in a north-east direction. It thence advanced in a north-east or east-north-east direction across the north-west angle of the Bay and passed over the F. L. V. *Star* and *Canopus*, both of which were carried away from their stations, and over the S.S. *Saint Regulus* and *Lincolnshire*, and the ships *Lena* and *Bann*, all of which suffered more or less severely from the hurricane winds and terrific sea. The Pilot vessel *Coleroon* foundered off the Orissa Coast during the night of the 5th. The storm was hence as severe and intense on the morning of the 6th as it was on the 31st and 1st.

It passed into Lower Bengal across the coast of the Sunderbunds to the east of Saugor Island and filled up with unusual rapidity, and the winds went down so quickly that little or no damage was done by the storm to the rice crops in South and East Bengal, whilst they benefitted largely from the rainfall which accompanied the storm. The storm filled up on the 7th in the Cachar, Sylhet and Mymensingh Districts of Assam and East Bengal.

The storm is of unusual interest, more especially on account of the following remarkable features :—

1st.—It originated in the Gulf of Siam outside the Indian area and passed across the Malayan Peninsula into the Andaman Sea and Bay of Bengal. It is the first large cyclonic storm of the Bay, for which there is clear and conclusive evidence that it originated outside the Bay area.

2nd.—The storm was in its earlier stages of small extent, although of great intensity. The winds were consequently of extraordinary violence. The storm increased in area as it approached the head of the Bay, but was of as great intensity when crossing the Sandheads as it was when in the Malayan Peninsula or the Andaman Sea. It had an existence of at least nine or ten days, during at least seven of which it was an intense cyclone or typhoon.

3rd.—The path in the Bay of Bengal was almost unique. The course or track was west-north-west on the 31st, 1st and 2nd. It curved rapidly through north-west to north on the 3rd and 4th, and thence to north-east and east-north-east on the 5th. In consequence of this recurvature several ships (*e.g.*, the ***Bann*** and *Lena*) encountered the storm twice in their passage up the Bay. It was also probably owing to this unusual recurvature (greater than in any storm in the Bay during the past 20 years) that the P. V. *Coleroon* foundered.

Brief account of the second storm.

The second storm, described in Chapter III, originated on the 1st and 2nd in the sea area between the Maldives and the Travancore coast. Light variable winds had prevailed in this area for some days previously, whilst steady and moderate north-east winds obtained over the whole of the north and centre of the Arabian Sea. Very heavy rain commenced to fall in the area of light variable winds on the 31st and 1st. A cyclonic whirl began to form in the area of heaviest rainfall on the 1st. It commenced to move westwards on the 2nd and passed to the north of Minicoy during the night of the 2nd. It thence advanced into a part of the Arabian Sea rarely traversed by ships, and no further information has hence been obtained of its progress. During the next four days southerly winds obtained off the Malabar and Konkan coasts, and gave squally weather with frequent thundershowers in the Malabar and Konkan coast districts and the adjacent sea area.

The storm is said to be the most violent that has been experienced in Minicoy for the past 25 years. It is interesting as showing the conditions that probably usually prevail in the south-east of the Arabian Sea during a period of squally, showery weather in Malabar in the month of November.

Brief account of the third storm.

The third storm, an account of which is given in Chapter V, originated in the south-east of the Bay on the 19th and 20th. North-east winds prevailed at that time over the north and centre of the Bay

South-west winds of increasing intensity had obtained in the south of the Bay for some days previous. Variable unsteady winds prevailed in the intermediate area to the west of the Nicobars and south-west of the Andamans. Weather became squally with heavy rain in this area, whilst southerly winds advanced up the east of the Bay. A cyclonic whirl rapidly formed and developed in this area on the 19th and 20th. It began to advance northwards, and at the same time intensified rapidly. It was a cyclone of moderate extent and considerable intensity on the 21st. The centre began to recurve to the north-east on the 22nd and crossed the Arakan coast south of Sandoway about 11 A.M. or noon of the 23rd. It filled up rapidly during its passage across the Arakan Yoma, and was a very shallow depression on the morning of the 24th. It was then in Central Burma, and was determining a moderate burst of rain to the greater part of Burma—of great value for the rice crops. It broke up during the day.

The storm formed under what might be termed the normal conditions of storm generation in November. It was remarkable only for its path. The usual track of cyclones in November is west or west-north-west to the Madras coast, and their path is approximately straight. The storm in question advanced by a curved path into Central Burma. The recurvature was of the same character, but much less in amount than that of the first storm of the month. The circumstances of both were equally abnormal, and hence indicate the presence during the whole month of certain persistent abnormal conditions influential in determining the tracks of the cyclonic storms of the period which it is attempted to trace out in the concluding chapter of the Memoir.

CHAPTER II.

The Meteorology of India antecedent to the Cyclonic Storms of November 1891.

Abnormal features of the meteorology of the cold weather months, 1890-91.

The weather in the Indian land region during the year 1891 was very abnormal in many respects. The winter or cold weather months of January, February and March were unusually cloudy and rainy in Northern India. The rainfall during this period was heavier over the greater part of Northern India than has been known for many years. Accounts received from the hill districts show that the winter snowfall was excessive. In Northern Afghanistan, and some parts at least of the North-Western Himalayas, the snowfall was, according to local accounts, one of the heaviest that has occurred for many years. The excessive character of the rainfall is indicated by the following returns for a few typical stations :—

DISTRICT.	Representative station.	RAINFALL FOR PERIOD JANUARY TO MARCH.			Ratio of actual to normal.
		Actual, 1892.	Normal.	Variation from normal in 1892.	
		Inches.	Inches.	Inches.	
PUNJAB . . .	Rupar . .	7·28	3·37	+3·91	2·2
	Hoshiarpur . .	8·80	4·66	+4·14	1·9
	Sialkot . .	11·13	4·35	+6·78	2·6
	Ludhiana . .	8·95	3·76	+5·19	2·4
	Nowshera (Peshawar) . .	10·55	5·42	+5·13	2·0
NORTH-WESTERN PROVINCES AND OUDH .	Ranikhet . .	9·92	6·36	+3·56	1·6
	Agra . .	2·74	0·90	+1·84	3·0
	Lucknow . .	3·89	1·49	+2·40	2·6
	Allahabad . .	2·73	1·21	+1·52	2·2
	Gorakhpur . .	4·74	1·12	+3·62	4·2
	Benares . .	2·94	1·13	+1·81	2·6
BIHAR . . .	Arrah . .	5·71	1·50	+4·21	3·8
	Dinapore . .	7·47	1·04	+6·43	7·2
	Motihari . .	5·16	1·37	+3·79	3·8
	Purnea . .	5·14	1·42	+3·72	3·6
	Bhagalpur . .	5·19	1·29	+3·90	4·0
	Jamtara . .	8·54	1·48	+7·06	5·8

The meteorological observations of the past 20 years have shown that excessive snowfall in the Himalayan and Afghan mountain region has a very marked effect upon the weather in India for some months afterwards.

Abnormal features of the meteorology of the hot weather months and the south-west monsoon, 1891.

The following hot weather months (April and May) are always, in years of excessive snowfall, cooler than usual in Northern India, and pressure decreases less rapidly than usual, and is consequently above the normal. These conditions are antagonistic to the advent of the south-west monsoon. Hence, as a further consequence the south-west monsoon sets in during such years later than usual, and there is a strong tendency for the following south-west monsoon rains to be very irregularly distributed and to be more or less deficient in large areas of Northern and Central India. The excessive snowfall in the hill districts during the months of January, February and March 1891, was followed by all these abnormal conditions, as is fully shown by the following data :—

1st.—Temperature was considerably below the normal in Northern India during the months of April and May 1891, the deficiency being greatest in the plain districts nearest to the mountain area of excessive snowfall. The following table gives variation data for th months for different provinces in Northern India :—

PROVINCE.	VARIATION OF MEAN TEMPERATURE FROM NORMAL IN THE MONTH OF	
	April 1891.	May 1891.
	°	°
Punjab	−2·7	−2·3
North-Western Provinces .	−1·4	−1·0
Rajputana . . .	−0·4	−0·8
Sind	+1·0	−0·5
Central India . . .	−0·2	−0·6
Bihar	−0·6	−0·3
Bengal and Orissa . .	+0·2	−0·6
Mean of Northern or Extra-tropical India . . .	−0·6	−0·9

2nd.—Pressure was considerably above the normal over the wh Indian region in April and May, and the excess was greatest in No Western India. The following table gives data establishing fact :—

PROVINCE.	VARIATION FROM NORMAL OF MEAN PRESSURE IN THE MONTH OF	
	April 1891.	May 1891.
	Inch.	Inch.
Punjab	+ ·050	+ ·040
Sind	+ ·020	+ ·038
Rajputana	+ ·036	+ ·032
Central India	+ ·032	+ ·023
North-Western Provinces . .	+ ·031	+ ·019
Central Provinces	+ ·035	+ ·016
Bihar	+ ·018	+ ·012
Bengal and Orissa	+ ·016	+ ·012
Whole of India	+ ·028	+ ·015
Tropical India	+ ·026	+ ·005
Extra-tropical India . . .	+ ·030	+ ·024

General character of the south-west monsoon rains in the period July to September 1891.

3rd.—The establishment of the south-west monsoon was very considerably retarded, more especially in Western and North-Western India. The following gives the approximate dates of the setting in of the monsoon rains in different provinces and the normal dates :—

Province.	Date of setting in of monsoon rains, 1891.	Normal date of setting in of monsoon rains.	Amount of retardation.
Bombay	21st June	5th June	16 days.
Central Provinces . . .	28th ,,	8th ,,	20 ,,
Central India	3rd July	10th ,,	23 ,,
Rajputana	5th ,,	12th to 15th June	21 ,,
North-Western Provinces . .	24th ,,	30th ,,	24 ,,
Punjab	25th ,,	3rd July	22 ,,

The preceding statement shows fully the great delay in the advance of the humid rain-giving monsoon current into Northern India. The delay ranged from a fortnight in the Bombay Coast districts to three weeks or a month in the Central Provinces, Central India, Rajputana, the North-Western Provinces and the Punjab.

4th.—The rainfall of the south-west monsoon period proper, *i.e.*, from June to September, was more irregularly distributed than usual. Some areas received excessive rainfall, whilst other areas obtained amounts not only much below the normal, but either so small in amount or so ill-timed as to be either insufficient for or injurious to the crops. The areas of deficient and excessive rainfall, it may be noted, were to a certain extent indicated by the variations of pressure from the normal in May and June.

The areas in which the rainfall was most excessive were—

(1) The North-Western Provinces, Bundelkhand and Baghelkhand.

(2) The greater part of the Central Provinces and Berar.

(3) Lower Burma and Arakan.

The areas of very deficient rainfall and of partial drought during the monsoon period were—

(1) West and Central Rajputana.

(2) Mysore and South and Central Madras.

(3) Upper Burma (probably).

The following gives average data of the rainfall of the south-west monsoon period June to September in the areas of most excessive and deficient rainfall and a comparison with the normal rainfall :—

DISTRICT.		RAINFALL FOR PERIOD JUNE TO SEPTEMBER.		
		Actual, 1891.	Normal.	Variation from normal in 1891.
		Inches.	Inches.	Inches.
Areas of most excessive rainfall.	Tenasserim . . .	199·64	153·44	+46·20
	Lower Burma . . .	104·52	77·07	+27·45
	Arakan	159·75	149·36	+10·41
	Central Provinces . .	50·02	43·65	+ 6·37
	North-Western Provinces .	33·40	32·65	+ 0·75
Areas of very deficient rainfall.	Madras (Central) . .	6·11	15·76	— 9·65
	Madras (South) . .	2·50	6·03	— 3·53
	Mysore	13·63	18·07	— 4·44
	Rajputana (East) . .	17·74	24·77	— 7·03
	Rajputana (West) . .	7·38	12·42	— 5·04

Over the remainder of India the total rainfall of the monsoon period did not differ largely from the normal amount. When it is remembered that the rains were upwards of a month later than usual in beginning, the excessive character of the downpour in the North-Western Provinces, the Central Provinces and the eastern states of Central India will be realized.

It will thus be seen that the rainfall of the south-west monsoon period was very irregular ; areas of drought and of excessive downpour alternating, and that in some of the areas of deficient rainfall the rainfall, that was received, occurred as heavy downpours for brief periods with longish intervals of dry weather.

5th.—The rains of the south-west monsoon period proper ceased almost simultaneously in the first week of October over the whole of Northern and Central India.

The following gives the dates of the last day of fairly general rainfall in each of the larger meteorological divisions or provinces of Northern and Central India :—

PROVINCE.	Date of last general rainfall of south-west monsoon, 1891.
Bengal	5th October.
Rajputana . . .	5th „
North-Western Provinces and Oudh .	5th „
Bihar	4th „
Central India	6th „
Punjab	4th „
Assam	5th „
Central Provinces . . .	6th „
North Bombay . . .	6th „

General character of the rainfall due to the retreating south-west monsoon current in the Bay in October 1891.

6th.—The rainfall of the retreating south-west monsoon in October was even more abnormally distributed than that of the south-west monsoon proper. As a rule, the retreating south-west monsoon current in October gives heavy rain to the North and Central Madras coasts, and moderate rain to the South Madras and Coromandel Coast districts. In October 1891, when rainfall was ceasing in Northern India, general and heavy rain commenced in South Madras and continued more or less steadily throughout the month. The intermediate area between Northern and Central India and South Madras (including the Deccan and North and Central Madras), received practically no rain after the first week of the month. The following data for a few stations show the striking contrast between the very deficient rainfall in the Northern and Deccan districts of Madras and the excessive rainfall in South Madras in October 1891:—

AREA.	STATION.	RAINFALL FOR OCTOBER.		
		Actual, 1891.	Normal.	Variation from normal in 1891.
		Inches.	Inches.	Inches.
NORTH MADRAS .	Vizagapatam .	1·50	10·30	—8·80
	Alamur . .	*Nil.*	9·11	—9·11
	Coringa .	1·20	11·90	—10·70
	Cocanada . .	1·05	10·06	—9·01
	Ellore .	0·68	6·72	—6·04
	Masulipatam .	4·99	8·85	—3·86
DECCAN . .	Bellary . .	1·00	4·27	—3·27
	Gooty . .	5·00	5·24	—0·24
	Cuddapah. .	2·55	6·81	—4·26
CENTRAL MADRAS	Nellore . .	3·00	11·41	—8·41
	Vellore .	11·82	8·37	+3·45
	Madras . .	13·42	12·62	+0·80
	Arcot . . .	9·59	6·55	+3·04
SOUTH MADRAS .	Cuddalore .	17·98	9·31	+8·67
	Tranquebar .	20·05	10·19	+9·86
	Negapatam .	14·70	10·17	+4·53
	Trichinopoly .	10·11	6·92	+3·19
	Madura . .	15·10	7·94	+7·16
	Tanjore . .	12·25	6·16	+6·09

Another noteworthy feature of the October rainfall was the very serious deficiency in Bengal, Assam and Bihar. Usually south-west humid winds obtain over the centre as well as the south of the Bay in October. These winds influence Bengal and Bihar so far as to give them occasional rain-showers throughout the month. Cyclonic storms also occasionally form or appear in the Bay of Bengal during the month, and usually give more or less general rain in Bengal. The normal course of these storms is west-north-west from the centre of the Bay to the Circars and Ganjam coasts or north into Bengal.

The following rainfall statement giving data of the actual and normal average rainfall in the Province of Bengal for the month of October, taken from the Bengal Weather Report for the month, shows the very serious deficiency in the rainfall of the month in that area :—

METEOROLOGICAL DIVISION.	RAINFALL OF OCTOBER.		
	Actual, 1891.	Normal.	Variation from normal.
	Inches.	Inches.	Inches.
Orissa	1·31	6·16	—4·85
South-West Bengal .	0·73	4·33	—3·60
East Bengal . . .	1·73	5·43	—3·70
North Bengal . .	2·02	4·38	—2·36
North Bihar . . .	1·37	3·54	—2·17
South Bihar . . .	1·50	3·30	—1·80
Chota Nagpur . .	0·53	2·97	—2·44

General character of the weather in the Bay of Bengal during the month of October 1891.

The weather in the Bay of Bengal in the month of October was abnormally quiet and not one cyclonic storm formed in it. Hence Bengal was deprived of this source of rainfall during the month. Also when the rains ceased in Northern India at the end of the first week of October, north-east winds extended with unusual rapidity over the whole of the north and centre of the Bay, and the humid winds in the south of the Bay merely gave squally weather with frequent rain to South Madras and the south of the Bay. The determination of the rainfall to South Madras is further indicated by the unusually small precipitation at Port Blair in the Andamans and Camorta in the Nicobars. The following gives data for these two stations :—

STATION.	Actual rainfall of October 1891.	Normal rainfall of October.	Variation from normal.
	Inches.	Inches.	Inches.
Port Blair	5·65	12·17	—6·52
Camorta	8·04	13·33	—5·29

The preceding remarks have shown that the meteorology of India from June to September 1891, was characterized by very marked features and variations from the normal conditions. They have also indicated that the rainfall of the month of October in the Peninsula, due to the retreating south-west monsoon, was very abnormally distributed. Little or no rain fell in the northern and central districts, which usually obtain heavy rain in October. The southern districts, on the other hand, received frequent showers, and the rainfall was in general excess in the districts of Tanjore, Trichinopoly, Madura and South Arcot. This very peculiar distribution of rainfall accompanied a very abnormal distribution of pressure which was very persistent and intensified in the last week.

The more important features of the normal and actual mean distribution of pressure of the month of October, and the actual mean distribution of pressure in October 1891, can be seen at once by inspection of the charts in Plates I, II and III, at the end of the volume.

The first two charts (Plate I) show by means of isobars drawn for pressure differences of ·05″ the normal distribution of pressure in October.

In the first chart the isobars indicate the mean distribution of pressure (as obtained from readings at 10 and 16 hours and the employment of corrections derived from the hourly observations taken at representative stations in India). The second chart gives the mean distribution of pressure at 8 A.M. in October. The chief features of the 8 A.M. distribution of pressure are almost identical with the mean distribution.

Chief features of normal distribution of pressure in the month of October in the Indian area. (Plate I, Charts 1 and 2.)

The chief features of the normal distribution of pressure in India in October are—

1st.—Great uniformity of pressure over the whole of India. Pressure is lowest in the Bay area and highest in Upper India, where it is nearly a tenth of an inch higher than over the centre of the Bay. Excluding Assam, Sind and the Punjab, the range of pressure in the Indian land area is less than five hundredths of an inch.

2nd.—Almost absolute uniformity of pressure over the Bay area, in which the mean range of pressure, so far as is indicated by the land observations, is almost certainly less than a hundredth of an inch. It may be noted that the accumulating observations show that the normal pressure of October in the Bay is even more uniform than was indicated by the shorter periods of observation available when discussing the Backergunge and other cyclones of the October transition period.

Statement of the abnormal features in the pressure distribution in the Indian area during the month of October 1891. (Plates II and III.)

The abnormal features of the pressure distribution of October 1891, are shown in Charts 1 and 2, Plate II, and in the pressure variation and anomaly charts (1 and 2) of Plate III.

The two charts in Plate II give similar information to that contained in Plate I for the month of October 1891, Chart 1 showing the mean daily distribution of pressure and Chart 2 the distribution at 8 A.M. in that month. It should be noted that in these charts the pressure has been not only corrected for temperature and reduced to sea-level, but has also been reduced to constant gravity (that of Lat. 45°). Chart 1 of Plate III gives the variations of pressure from the normal by means of lines of equal pressure variation drawn for differences of ·02″, continuous lines denoting increased pressure or positive variations and broken lines negative variations. Two parallel lines close together, one continuous and the other broken, is the line of no variation.

Chart 2 of Plate III shows the pressure anomalies or local variations of pressure over the whole Indian area after allowance has been made for the general excess of pressure, which was one of the more important features of the pressure distribution in the Indian area in October 1891.

The following gives the chief features in the distribution of pressure in October 1891 :—

(1) The mean pressure of the month of the whole Indian area was considerably in excess, by amounts averaging 0·36″.

(2) The excess was greatest in Berar, the Central Provinces and the North Deccan, and hence there was a moderately large local excess of pressure in that area.

(3) The excess was least in amount in Burma, the Andamans and Southern India, and hence there was a moderate local deficiency of pressure which was greatest in Malabar and across the south and south-east of the Bay.

In consequence of these peculiar features the mean distribution of pressure in October 1891 differed in some important respects from the normal distribution, *e.g.*,—

1st.—The range of pressure over India was considerably greater than usual.

2nd.—Pressure was less uniform in the Bay than usual and was high in the north-west of the Bay, so that there were slight gradients favouring the prevalence of steady northerly winds.

3rd.—Pressure was somewhat lower in the east than in the west of the Bay, thus giving pressure relations between the Burma and Madras coasts opposite to those which usually obtain in October. The following data show this deficiency of pressure at the east coast as compared with the west coast stations of the Bay :—

STATION.	Mean pressure reduced to sea-level and to gravity 45° Lat.	STATION.	Mean pressure reduced to sea-level and to gravity 45° Lat.
	Inches.		Inches.
Saugor Island .	29·853	Akyab . .	29·847
Vizagapatam .	·849	Diamond Island	·837
Madras . .	·835	Port Blair .	·818
		Mergui . .	·821

Chief features of the air movement in October 1891.

These strongly marked variations of the pressure distribution of the month from the normal accompanied largish variations of the temperature and humidity conditions, and of the air movement over India during the month. The following gives a brief statement of the important variations from the normal in these features. Westerly winds set in over the Gangetic Plain during the second week of the month, and extended rapidly eastwards into Bengal and prevailed with abnormal steadiness during the remainder of the month. Winds were hence stronger and steadier than usual in Bengal and the Gangetic Plain, the increased steadiness being most marked in Bihar, where winds are generally very unsteady in October.

The following gives wind data for four representative stations in Northern India:—

PROVINCE.	STATION.	WIND DIRECTION.		MEAN STEADINESS.		TOTAL DAILY WIND VELOCITY IN MILES.	
		Actual.	Normal.	Actual.	Normal.	Actual.	Normal.
				%	%		
NORTH-WESTERN PROVINCES.	Allahabad .	N. 57° W.	N. 42° W.	34	13	43	41
BIHAR . .	Patna . .	N. 79° W.	N. 21° E.	21	4	52	45
BENGAL . .	Berhampore .	N. 65° W.	N. 12° W.	47	16	47	51
	Saugor Island	N. 32° W.	N. 10° E.	43	13	199	156

Winds were even more abnormal in Burma, where southerly winds generally continue until the end of the month. In October 1891, southerly winds withdrew at the end of the second week of the month, and were replaced by northerly winds; winds were steadier and on the whole stronger than usual. The following gives mean wind data for Port Blair and three stations in Lower Burma:—

STATION.	MEAN DIRECTION.		MEAN STEADINESS.		TOTAL DAILY WIND VELOCITY IN MILES.	
	Actual.	Normal.	Actual.	Normal.	Actual.	Normal.
			%	%		
Port Blair. . .	S. 69° E.	S. 5° W.	38	24	99	149
Mergui . . .	N. 4° E.	S. 79° W.	37	22	52	35
Akyab . . .	N. 28° E.	S. 35° E.	31	12	60	58
Rangoon . . .	N. 31° W.	S. 46° E.	14	27	72	76

Winds were very light and irregular in Central India and the Central Provinces. They were very abnormal in Madras, more especially at the southern stations, where the winds of the month contained an usually strong northerly or easterly element. This was evidently due to the position of the area of low pressure in south of the Bay instead of in the centre. The following data i trate this feature :—

STATION.	MEAN DIRECTION.		MEAN STEADINESS.		TOTAL DAIL WIND VELOCIT MILES.	
	Actual.	Normal.	Actual.	Normal.	Actual.	Nor
		°	%	%		
Madras . . .	N. 55° E.	N. 35° E.	58	10	128	12
Trichinopoly . .	N. 44° E.	N. 45° W.	23	36	85	9
Salem . . .	N. 72° W.	S. 52° W.	63	39	57	6.
Negapatam . .	N. 32° W.	S. 51° W.	29	30	72	8

Temperature conditions, October 1891.

Temperature differed little from the normal in October, but generally in defect, due chiefly to the excessive rainfall of the moı of August and September. The following gives a statement of temperature data of the month:—

DIVISION.	VARIATION OF			ACTUAL.		
	Mean maximum temperature from normal.	Mean minimum temperature from normal.	Mean temperature from normal.	Mean maximum.	Mean minimum.	Me temp tur
	°	°	°	°	°	
Burma Coast and Bay Islands . . .	+1·1	—0·7	+0·2	89·1	74·4	81
Burma Inland. . .	+1·1	—5·0	—2·0	90·4	70·7	8
Assam	—0·5	—2·4	—1·5	86·0	69·8	77
Bengal and Orissa . .	+0·6	—2·0	—0·7	87·6	71·6	79
Gangetic Plain and Chota Nagpur . . .	—0·6	—1·8	—1·2	88·0	68·0	78
Upper Sub-Himalayas .	—4·7	+0·3	—2·2	85·7	62·6	74
Indus Valley and North-West Rajputana. . .	—0·7	+1·6	+0·5	94·6	66·9	8
East Rajputana, Central India and Guzerat .	—0·9	—0·1	—0·5	91·1	67·2	79
Deccan	—0·3	—1·2	—0·8	87·9	65·1	76
West Coast . . .	+1·7	—0·7	+0·5	87·1	72·8	8
Southern India . .	—0·3	+0·1	—0·1	87·6	73·0	8

Humidity conditions, October 1891.

The air was much drier than usual, and the cloud amount m below the average in North-Eastern India, and to a less extent in

Deccan and West Coast Districts. The following table gives comparative data :—

DIVISION.	VARIATION OF		CLOUD AMOUNT.	
	Aqueous vapour pressure from normal.	Relative humidity from normal.	Actual.	Variation from normal.
	Inch.			
Burma Coast and Bay Islands	—.009	—3	4·5	—1·3
Assam	—·046	—1	3·5	—0·9
Bengal and Orissa	—·077	—8	3·2	—1·2
Gangetic Plain and Chota Nagpur	—·009	0	2·1	—0·6
Upper Sub-Himalayas	+·050	+10	1·7	+0·9
Indus Valley and North-West Rajputana	+·016	+1	1·1	+0·4
East Rajputana, Central India and Guzerat	+·048	+5	1·5	—0·3
Deccan	— 017	0	3·1	—0·9
West Coast	—·034	—3	2·6	—1·4
Southern India	+·009	0	6·5	+0·4

Rainfall, October 1891.

The Punjab received a moderate burst of rain in the first week of the month, which gave it more than the normal rainfall. The rainfall of the month was more or less in defect in all other districts except the west coast and some parts of South Madras. The deficiency was most marked in Bengal and Bihar. The following table indicates fairly the distribution of the rainfall of the month :—

DIVISION.	RAINFALL.			
	Mean Rainfall of month.	Mean Normal rainfall of month.	Variation from normal.	Percentage ratio of actual to normal.
	Inches.	Inches.	Inches.	
Burma Coast and Bay Islands	5·90	9·53	—3·63	62
Burma Inland	2·67	4·44	—1·77	60
Assam	3·30	4·49	—1·19	73
Bengal and Orissa	1·75	5·18	— 3·63	34
Gangetic Plain and Chota Nagpur	1·68	2·81	—1·13	60
East Rajputana, Central India and Guzerat	0·66	0·88	—0·22	75
Deccan	2·40	3·02	—0·62	80
West Coast	10·25	7·48	+2·77	136
South India	7·86	8·16	—0·30	96

In the preceding remarks the chief features of the distribution of pressure in October 1891 have been stated. The excess of pressure in the Indian area was in part due to the heavy rainfall of the preceding month, and the cessation of the rains in Northern and Central India at the end of the first week of October. The relations of pressure changes to rainfall are very frequently marked in India. One of these relations is the rise which occurs immediately after the occ rence of very heavy rain either on the large or small scale. The ra fall of September was very heavy over a large part of India, and excessive in the Central Provinces. Pressure was slightly in defect the Indian area in September, and was locally in defect in the Cen Provinces, Baghelkhand, Bundlekhand and adjacent portions of North-Western Provinces. This area of local deficiency of press was also the area of abnormally heavy rain. The cessation rainfall in Northern and Central India in the first week of Oc ber was followed by a general increase of pressure in Northern Central India and a considerable local excess in the Central Provin

Brief summary of the most important abnormal features during period January to October 1891.

The following gives a brief summary of the most important normal features of the meteorology of the period January to Octo 1891, described in the preceding paragraphs:—

1st.—Excessive snowfall in the mountain regions adjoin North-Western India, and much heavier rain than us in Northern India during the months of January, F ruary and March.

2nd.—Drier and somewhat cooler weather than usual in hot weather months of April and May in Northern In

3rd.—Protracted delay in the setting in of the monsoon ra over the whole of Northern and Central India. months of June and July were hence abnormally dry a hot over the interior of Northern and Central India, the Central Provinces, North Deccan, Central India, R putana, the North-Western Provinces and the Punja

4th.—Very abnormal distribution of rainfall during the sou west monsoon proper. Lower Burma, the North We ern Provinces, East Punjab, East Rajputana and Central Provinces received excessive rain; West a Central Rajputana, Madras, and Upper Burma very d cient rain; and Bengal very irregularly-distributed ra

5th.—The south-west monsoon rains ceased abruptly, a almost simultaneously, over the whole of Northern a Central India at the end of the first week of Octobe

6th.—The immediate and sudden transfer of rainfall due to retreating south-west monsoon to South Madras the end of the first week of October. The intermedi areas of the Deccan, and North and Central Madras ceived little or no rain during the remainder of the mon This was associated with certain peculiar features pressure distribution stated in the preceding pa graphs.

7th.—Abnormally quiet weather in the Bay of Bengal during the month of October. In consequence of the non-occurrence of cyclonic storms North-Eastern India received practically no rain during the last three weeks of the month.

The weather in the month of October 1891 was hence very remarkable. It was largely dependent upon, and related to, abnormal pressure conditions in India. As these pressure conditions were very persistent during the month, and intensified during the last week of the month and were hence largely influential in determining the tracks of the cyclonic storms in November, it appears to be desirable to give a brief account of the weather in the Bay of Bengal and Arabian Sea during the month, drawn up from the marine data collected from vessels entering the Ports of Calcutta and Bombay, and a statement of the chief features of the meteorology of India during the last three days of the month.

Summary of weather in the Bay of Bengal in October 1891.

At the commencement of the month light variable winds (force 1 to 3) prevailed over the whole of the Bay of Bengal excepting in the south and south-east, where weather was squally with moderate west to west-south-west winds. Winds became lighter in the north of the Bay during the next three or four days, and on the 5th light airs and calms obtained in the north and centre of the Bay. Occasional heavy rain-showers were experienced at this time in different parts of the Bay. For example, the ship *Duchess of Edinburgh*, in Lat. 14° 10′ N. and Long. 89° 52′E. on the 7th, had light variable airs and very heavy rain in the morning. The S. S. *Ramose Head*, in Lat. 10° 21′N. and Long. 95° 54′E. on the 10th, had heavy rain squalls.

Light north-north-east to north-east winds set in at the head of the Bay on the 8th and extended rapidly southwards. Light to gentle north-east breezes or variable airs obtained over the north and centre of the Bay on the 9th and 10th. On the 11th light north-east winds prevailed over the greater part of the Bay. Strongish south-west winds continued off the Ceylon coast, and weather was squally there and in the south of the Bay generally. No change occurred during the next few days, except that the north-east winds appeared to strengthen steadily. North-east winds (force from 1 to 4) prevailed on the 16th over the north and west of the Bay. Weather was also more squally in the south and south-east of the Bay. The ship *Skelmorlie*, in Lat. 15° 59′N. and Long. 90° 29′E. on the 19th, had south winds and very heavy squalls. The weather became more unsettled and squally during the next four days, and the majority of vessels in the south and centre of the Bay reported squalls with more or less heavy rain. The S. S. *Glencona*, in Lat. 16° 1′N. and Long. 91° 41′ E.

on the 21st, had thick rainy weather. The *S. S. Clan Mackintosh*, in Lat. 1° 21'N. and Long. 80° 26'E. on the 21st, had very heavy rain, and on the 22nd, when off Madras, had torrents of rain. During this period, light north-east or variable winds with clear weather obtained in the north of the Bay.

Weather improved on the 25th. Light to moderate north-east winds obtained during the remainder of the month over the greater part of the Bay. Weather was squally off the Coromandel Coast, and moderate but somewhat unsteady south-west to south-east winds prevailed in the south-east of the Bay.

Summary of weather in the Arabian Sea in October 1891.

Light, unsteady and variable winds prevailed over the greater part of the Arabian Sea at the beginning of the month. Weather was squally in the south and south-east, off the Malabar Coast. Thus the S.S. *Argus*, in Lat. 18° 19'N. and Long. 76° 59'E. on the 4th, had frequent hard squalls from the west-north-west (force 6). On the 5th, light north-east or variable winds obtained to the north of Lat. 12°N. The winds increased in force on the 6th and 7th, and on the 8th the S. S. *Indrapura*, in Lat. 15° 54'N. and Long. 57° 52'E., had fresh easterly winds and occasional heavy rain squalls, and the S. S. *Egremont Castle*, in Lat. 15° 24'N. and Long. 58° 42'E., had hard squalls. Similar weather was experienced for some days in that part of the Arabian Sea. On the 13th light to moderate north-east monsoon winds obtained over the Arabian Sea to the north of Lat. 9° or 10°N. Further south winds were very unsteady and weather was showery. Off the Malabar coast weather continued squally with frequent rain. Thus the S. S. *Cathay*, in Lat. 8° 27'N. and Long. 76° 23'E. on the 16th, had squally weather and continuous heavy rain during the day, and the *Lorna Doone*, in Lat. 10° 24'N. and Long. 68° 14'E., had variable winds with heavy squalls. North-east winds (force 2 to 4) prevailed over nearly the whole of the Arabian Sea to the north of Lat. 8°N. during the third week of the month, and weather was fine except off the Malabar and West Ceylon coasts, where it was squally and showery. Strong east-north-east winds (force 6) were experienced by the S.S. *Netherley Hall* in the Gulf of Aden on the 17th.

No important change appears to have occurred in this sea area during the remainder of the month. Weather continued squally with unsteady winds off the Malabar and Ceylon coasts and probably in and to the north of the equatorial belt, but was fine with light to moderate winds in the centre and north of the Arabian Sea.

The wind data of the first six days of the month indicate that the winds shifted rather rapidly from west through west-north-west and north-west to north and north-east, when the south-west monsoon current retreated from the north and central area (between Socotra and Bombay) of the Arabian Sea.

The following gives in brief detail the chief features of the meteorology of the Indian area during the last three days of the month.

The pressure changes were fairly regular during the last fortnight of October. Pressure increased from the 16th to the 19th, fell from the 20th to the 22nd, increased on the 23rd and 24th, and decreased on the 25th. It increased again on the 26th and 27th, and gave way slightly on the 28th. It was largely in excess of the normal on the 28th. Weather was fine, winds light, and skies clear at this time over the whole of India with the exception of South Madras, where skies were clouded and frequent showers were falling.

Chief features of the meteorology of India on 29th October.

29th October.—Pressure had given way locally during the previous 24 hours in Upper India. A very shallow depression covered Sind and the South-West Punjab on the morning of the 29th. Pressure was very uniform in the Bay. Very light winds and calms were registered in the Punjab, and light unsteady winds in the Gangetic plain. Winds ranged between north and north-west in the west and north coast districts of the Bay. North-west winds had been unusually prevalent at the Coromandel Coast stations during the preceding week.

The following table gives the mean variations of pressure and temperature from the normal, the mean air movement and mean amount of cloud in different provinces :—

PROVINCE.	Variation of mean actual pressure from normal.	Mean pressure anomaly.	Variation of mean temperature from normal.	Mean cloud amount.
	Inch.	Inch.	°	
Burma	+·005	−·024	−1·5	1·1
Bengal and Assam . .	+·026	−·003	+1·0	3·0
North-Western Provinces .	+·027	−·002	−1·7	1·7
Punjab	−·003	−·032	−1·9	0·7
Central Provinces . . .	+·033	+·004	+3·0	3·1
Guzerat and Central India .	+·035	+·006	−1·1	0·1
Sind and Rajputana . .	+·026	−·003	−1·3	0
Bombay	+·041	+·012	+1·7	3·4
Madras	+·055	+·026	+0·5	2·6

The mean pressure of the Indian area was ·029" above the normal of the day. Pressure was locally in moderate defect in Burma and the Punjab, and in moderate excess in Madras or the southern half of the Peninsula. Skies were clear in North-Western India, and were lightly clouded in the Peninsula and North-Eastern India. Light showers had fallen in some districts of South Madras and in Travancore, but the amounts were generally small.

The marine data indicate that weather was fine with light winds over the north and centre of the Bay, and that it was squally with unsteady south-west winds in the south of the Bay.

Chief features of the meteorology of India on the 30th October. (Plate IV, Charts 1 and 2).

30th October.—The barometric changes of the next 24 hours were everywhere small in amount and made no important change in the pressure distribution. Temperature decreased from 1° to 6° over the whole of North-Eastern and Central India and the North Deccan. Some showers were again received in South Madras and Malabar. In Lower Burma the barometer was steady, winds light, but normal in direction (ranging between north and north-east), and skies clear, or very lightly clouded.

The mean pressure of the Indian land area was ·041" in excess. The local anomalies were unchanged in general character. The deficiency in Burma was more marked, and the excess in the east and centre of the Peninsula was more general than on the previous day. Charts 1 and 2, in Plate II, show the 8 A.M. distribution of pressure and of the pressure anomalies of this day.

The following gives mean data showing that the general meteorological features were unchanged :—

PROVINCE.	Variation of mean actual pressure from normal.	Mean pressure anomaly.	Variation of mean temperature from normal.	Mean cloud amount.
	Inch.	Inch.	°	
Burma	−·001	−·042	−0·6	1·5
Bengal and Assam . . .	+·046	+·005	+0·1	1·7
North-Western Provinces .	+·062	+·021	−2·5	0·6
Punjab	+·015	−·026	+0·1	3·8
Central Provinces . . .	+·064	+·023	−0·2	1·8
Guzerat and Central India .	+·054	+·013	−2·4	0
Sind and Rajputana . .	+·024	−·017	−0·1	0
Bombay	+·027	−·014	+1·5	3·8
Madras	+·062	+·021	+1·1	4·0

An important feature was the decrease of cloud in North-Eastern and Central India which had taken place during the previous 24 hours.

Chief features of the meteorology of India on the 31st October. (Plate V).

31st October.—A brisk to rapid increase of pressure occurred during the next 24 hours. The rise was greatest in Upper India. These changes modified the distribution of pressure considerably. The shallow depression which lay over Sind on the 29th and 30th had filled up, and pressure was now highest in the North Punjab, East Rajputana and Central India, where it slightly exceeded 30·10 .

The increase of pressure on the 31st was greatest in the Punjab, and decreased with approximate uniformity southwards. It was very uniform over the whole of Central and North-Eastern India and Burma, and it is hence possible, although so far as can be judged from the small extent of the storm which was approaching the Andaman Sea from the Gulf of Siam, not probable, that a portion of the excess in Burma and North-Eastern India may have been due to outflow from the cyclonic storm.

The following table gives variation data for the 31st :—

PROVINCE.	Variation of mean actual pressure from normal of day.	Anomaly.	Variation of mean temperature from normal of day.	Mean cloud amount.
	Inch.	Inch.	°	
Burma	+ 087	—·024	—0·6	1·0
Bengal and Assam . . .	+·122	+·011	+0·1	0·4
North-Western Provinces .	+·128	+·017	—2·5	0
Punjab	+ 117	+·006	+0·1	0·8
Central Provinces . . .	+·129	+·018	—0·2	.8
Guzerat and Central India .	+·112	+·001	+2·4	0·3
Sind and Rajputana . .	+·107	+·006	—0·1	0·4
Bombay	+·087	-·024	+1·5	4·2
Madras	+·109	+·002	+1·1	3·6

Chart 1, Plate V, exhibits the actual distribution of pressure at 8 A.M. of the 31st. The chart shows that moderately steep gradients obtained in the west of the Peninsula and the north of the Bay. Winds were light in the Gangetic plain and North-Western India. Moderate north winds prevailed in Bengal and Burma, and moderate easterly winds in the Deccan. Skies had cleared in North-Eastern India, and were very lightly clouded in Burma. They were partially clouded in the south of the Peninsula, but rain had almost ceased to fall there.

Chart 2, Plate V, gives the distribution of the pressure anomalies of the 31st. This chart shows that there was a considerable excess of pressure in the central part of the Indian land area extending from the South-east Punjab to the coast of the Circars. This area of local excess of pressure had been a persistent feature for some time and was hence a permanent feature of the meteorology of India for several days antecedent to the arrival of the Port Blair cyclone in the Indian area.

Weather in the Bay of Bengal and Arabian Sea on 31st October.

The following tables give a summary of the observations tal by ships in the Bay of Bengal and Arabian Sea on this day :—

Bay of Bengal.

NAME OF VESSEL.	POSITION. 8 A.M.		BAROMETER. 8 A.M.		WIND. 8 A.M.		WEATHER.
	Latitude. N.	Longitude. E.	Actual.	Corrected and reduced to sea level and constant gravity.	Direction.	Force.	
	° ′	° ′	Inches.	Inches.			
S. *Loudon Hill*	4 30	93 7			W.	1	Unsteady winds heavy rain.
S. S. *St. Regulus* . .	7 39	98 6			N.-W.	2	Clear.
S. S. *Lincolnshire* . .	8 26	82 57	29·96	29·86?	N.	2	Very heavy rain unsteady wind.
S. S. *Congella* .	10 47	81 3			E.-N.-E.		Rainy and squally.
S. S. *Colaba* .	16 17	94 12	29·98	29·93	N.-E.	2	Fine.
S. S. *Ganges* .	16 36 (Noon.)	83 36	30·13	29·99	N.-E.	4	Fine with passing clou
S. S. *Chelydra*	17 51	90 37	30·26		N.-E.	4	Fine.
S. S. *Highfield*	19 1	86 43			N.-E.	4	Fine and clear.
S. S. *Thisbe* .	19 50	87 30	30·09		N.-E.		
S. S. *Charles Dickens* .	20 7	88 4	29·87	30·00	N.-E.	3	
S. *Tasmania* .	20 9	87 47	30·17	30·04	N.-E.	2	Fine.
S. S. *Nowshera*	A little to north of Saugor.		30·00		N.-N.-E.	2	Cloudy.

Arabian Sea.

NAME OF VESSEL.	Latitude. N.	Longitude. E.	Actual.	Corrected and reduced to sea level and constant gravity.	Direction.	Force.	WEATHER.
S. S. *Fultala* .	0 12S	73 54	30·15	29·90	E.-S.-E.	2	Cloudy.
S. S. *Venetia* .	6 35 (Noon.)	78 59	30·00		Var.	2	Overcast.
S. S. *Rohilla* .	8 51 (Noon.)	69 50	29·98		Var.	2	Overcast.
S. S. *Guayacan*	10 59	64 26	29·14?		N.	1	Fine.
S. S. *Lombardy*	11 59	75 0	29·98		Var.	2	Fine.
S. S. *Rajputana*	14 29	66 17	30·34		S. E. by S.	4—5	Cloudy.
S. S. *Lady Havelock* .	15 40	58 43	30·20		E.-N.-E.	3	Fine.
S. S. *Aurora* .	16 12	65 15			N.-E.	2	Fine.
S. S. *Pekin* .	17 38	64 47	30·12		N.-E.	2	Fine.
S. S. *Mobile* .	17 40	66 11	30·00		N.-W.	2	Fine.
S. S. *Etolia* .	18 39 (Noon)	58 17	29·75		S.	2	Fine.
S. S. *Calder* .	24 38	59 30	29·68		W.	2	Hazy.
S. S. *Kilwa* .	25 55	57 07	30·00		S.-E.	2	Fine.

The two preceding statements indicate that fine and apparentl settled weather with light to moderate north-east winds prevailed ove nearly the whole of the Arabian Sea and Bay of Bengal on the 31s Weather was cloudy with showers in the extreme south, but this was i no way abnormal. Over the greater part of the two sea areas weathe was much finer than usual in October.

The following statement giving 8 A.M. observations at the observatories on the coast of the Andaman Sea shews that weather was fine at that hour in Lower Burma, Tenasserim and the Andamans. They give no indication of approaching bad weather:—

STATION.	PRESSURE.			WIND.		HUMIDITY.		Amount of cloud at 8 A.M.	Rainfall in past 24 hours.	WEATHER.
	8 A.M.	Change in past 24 hours.	Variation from normal of day.	Direction.	Average velocity in miles per hour.	8 A.M.	Change in past 24hours			
	Inches.	Inch.	Inch.						Inch	
Camorta .	29·951	+·025	?	Calm.	4	86	—11	10	0·07	Cloudy.
Port Blair .	29·899	+·048	?	N.-N.-E.	5	88	— 2	4	0·16	
Diamond Island.	29·950	+·074	+069	N.-E.	5	79	+ 6	3	*Nil.*	Sea slight.
Moulmein .	29·962	+·090	+064	N.-W.	3	85	—13	0	0·41	
Tavoy .	29·932	+·063	?	Calm.	1	85	— 1	0	*Nil.*	
Mergui .	29·928	—·018	?	N.-N.-E.	2	94	+ 6	9	*Nil.*	

General character of weather at the end of October 1891 in the Indian sea area.

The weather at the end of the month was such as is usually experienced during the last fortnight of November or beginning of December (*i.e.*, towards the end of the retreating south-west monsoon). Light south-west to west winds were blowing at the entrance to the Bay as far north as Lat. 5°. Light variable airs prevailed from that latitude to Lat. 9° or 10° N. In this belt of calms and variable winds skies were clouded and showers were of occasional occurrence. Pressure was very uniform over this belt and in the Andaman Sea, and thence increased northwards to the head of the Bay. The southerly gradients were steeper than they usually are in October, and hence moderate north-east winds obtained over the north and west of the Bay. Weather was fine, skies clear and the sea generally smooth.

CHAPTER III.

Cyclonic Storm in the Arabian Sea from the 1st to the 3rd November.

Origin of the storm.

The information respecting this storm is exceedingly limited. It apparently formed off the Malabar coast on the 1st and 2nd, and advanced westwards through the Nine degree Channel immediately to the north of Minicoy, and thence passed into a part of the Arabian Sea rarely traversed by vessels. The storm is interesting, as it shows the existence at this time of a strong humid current in the south-east of the Arabian Sea and hence that the south-west monsoon currents were still in possession of the sea area to the north of the equatorial belt.

Conditions in the Arabian Sea prior to the storm.

The general conditions of the weather in the Arabian Sea during the month of October have been stated in the preceding chapter. During the last week of the month weather was fine with light to moderate north-east winds (force 2 to 5) over the whole sea area to the north of Latitude 10° N.

The following extracts from the log of the S.S. *Athens* crossing the Arabian Sea from Socotra to Ceylon at this time show very clearly the weather in the centre of the Arabian Sea immediately antecedent to the storm :—

Month and Date.	Hour.	POSITION AT NOON.		Barometer corrected and reduced to sea level and constant gravity.	WIND.		WEATHER REMARKS.
		Lati-tude. N.	Longi tude. E.		Direc-tion.	Force.	
				Inches.			
Oct. 29th	4 A.M.	...	...	...	N.-E.	2	Clear.
	8 A.M.	...	...	29·96	N.-E.	2	
	Noon.	13° 2′	60° 40′	...	N.-E.	1	Lightning.
	4 P.M.	...	...	...	N.-E.	1	Clear.
	8 P.M.	...	...	29·96	N.-E.	4	Cloudy.
	Midnight.	...	...	...	N.-E.	5	Cloudy.
30th	4 A.M.	...	...	...	N.-E.	4	Clear.
	8 A.M.	...	...	29·92	N.-E.	4	Clear.
	Noon.	12° 23′	63° 46′	...	N.-E.	2	Moderate sea.
	8 P.M.	...	...	29·90	N.-E.	2	Cloudy.
	Midnight.	...	...	...	E.-N.-E.	5	Cloudy.
31st	4 A.M.	...	...	...	Variable.	2	Cloudy.
	8 A.M.	...	...	29·90	N.-E.	4	Cloudy.
	Noon.	11° 14′	67° 15′	...	N.-E.	5	Cloudy.
	8 P.M.	...	...	29·90	N.-E.	5	Overcast.

Weather was fine with light to moderate north-east winds over the north and centre of the Arabian Sea. It was showery with light unsteady winds off the Travancore and West Ceylon coasts, and probably over the south-east portion of the Arabian Sea.

Meteorology of 1st November in the

November 1st.—The first indications of the formation of the depression and storm under discussion were shown on this day off the Malabar Coast. The barometer had fallen slightly during the previous 24 hours. Skies were more clouded and the wind had shifted from north-north-east to south-south-west at Colombo.

South-east of the Arabian Sea. (Chart I., Plate VI.)

The following gives available 8 A.M. observations for this area :—

STATION.	BAROMETER.			WIND.			TEMPERATURE.				Cloud proportion.	Rainfall in past 24 hours.	WEATHER.
	Actual reduced to sea level and constant gravity (Lat. 45°).	Change since 8 A.M. previous day.	Variation from normal.	Direction.	Average velocity in miles per hour.	Percentage ratio of actual to normal.	Maximum.	Variation from normal.	Minimum.	Variation from normal.			
	"	"	"				°		°				
Colombo .	29·930	—·007	+·079	SSW	4	67	84·5	?	75·0	?	4	0·05	Sea slight.
Trivandrum	29·900	—·012	?	NNE	6	?	83·0	?	68·5	?	10	*Nil.*	
Cochin .	29·899	—·008	+·057	NEN	2	?	88·2	+2·5	74·7	+0·6	5	1·29	Sea slight.
Minicoy .	29·843	—·047	?	...	13	?	78·2	?	75·8	?	10	*Nil.*	Drizzling.

These observations show that pressure was above the normal, and that the pressure changes of the previous 24 hours were small and unimportant except, perhaps, at Minicoy, where pressure was giving way briskly. North to north-east winds prevailed at Minicoy, Cochin and Trivandrum, and winds had strengthened considerably and were blowing freshly at Minicoy. Skies were cloudy and weather showery.

The following table gives a summary of 8 A.M. observations taken on board vessels in the south and centre of the Arabian Sea:—

NAME OF VESSEL.	POSITION.		BAROMETER.		WIND.		STATE OF SEA.	WEATHER.
	Latitude.	Longitude.	Actual.	Corrected and reduced to sea level and constant gravity.	Direction.	Force.		
	° ′	° ′	Inches	Inches				
S.S. *Fultala* .	2 35	76 42	30·18	29·93	W-S-W.	4		Rain squalls.
S.S. *Plassey* .	6 33	78 16	...	...	S.-E.	2		Fine.
S.S. *City of Vienna* .	7 17	74 31	29·76	29·80?	S.	3		Overcast with light rain and passing squalls.
S.S. *Wildcraft* .	7 33	78 47	...	...	Calm.	0		Rainy appearance.
S.S. *Nizam* .	8 52	76 27	30·20	29·90	N.-N.-E.	3		
S.S. *Drummond*	10 2	63 13	30·21	29·91	E. by N.	2	Smooth.	Fine and clear.
S.S. *Khandalla*.	at Cochin		30·24	29·90	E.	1		
S.S. *Manora* .	11 46	60 49	30·01	29·93	N.-N.-E.	4		Fine.
S.S. *Bohemia* .	12 49	53 33	30·16	30·05	E.	2		Fine.
S.S. *Ursa* .	(12 51	74 54)	...	...	Calm.	0	Smooth.	
	noon							
S.S. *Athens* .	10 15	70 10	30·06	29·88	Variable.	1		Light variable winds and overcast.

The preceding data establish that weather was fine with light winds off the west-coast and in the Arabian Sea to the north of Lat. 9° N or 10° N. It was showery and squally to the west of the Ceylon coast, where light southerly winds were blowing. The barometric observations at Minicoy and on board the S. S. *City of Vienna* establish that there was a shallow depression between Minicoy and the adjacent mainland. The chart of the day (Plate VI) shows the position and character of the depression.

The S. S. *Athens* and *City of Vienna* were approaching the central depression—the former advancing in an east-south-east direction towards it and the latter proceeding in the opposite direction towards and across it.

The following gives the whole of the meteorological information of the 1st in their logs :—

NAME OF VESSEL.	Hour.	POSITION.		Barometer Corrected and reduced to sea level and constant gravity.	WIND.		WEATHER.
		Latitude. N.	Longitude. E.		Direction.	Force.	
		° ′	° ′	Inches.			
S. S. Athens.	4 A.M.	...	...	...	Variable	1	Overcast.
	8 A.M.	10 15	70 10	29·88	Do.	2	Do.
	Noon	954	70 34	...	Do.	5	
	4 P.M.	...	...	29·88	Do.	5	Overcast and occasional squalls.
	8 P.M.	...	...	...	Do.	5	Overcast with fresh variable winds. Heavy thunder and slight confused sea.
	9 P.M.	...	...	...	Do.	...	Fierce squalls and downpour of rain. Heavy thunder and lightning.
	9-40 P.M.	...	...	...	Do.	...	Thick heavy rain.
	Midnight.	...	...	...	Do.	5	Squalls with incessant rain.
S. S. City of Vienna.	4 A.M.	...	...	...	W.	3	Overcast; light rain and passing squalls.
	8 A.M.	...	...	29·80 ?	S.	3	Ditto ditto.
	Noon	7 6	75 25	29·89 ?	Variable	2	Cloudy sky; passing squalls and slight sea.
	4 P.M.	...	...	29·93 ?	E.	...	Ditto ditto.
	8 P.M.	...	...	29·89 ?	E.	...	Passing squalls with incessant rain.
	Midnight.	...	...	29·91 ?	Variable	3	Ditto ditto.

Special observations at Minicoy on 1st November.

The observer at Minicoy commenced to take observations at short intervals from noon of the 1st, when the weather appeared to him suggestive of the approach of a storm. His observations show that pressure was very steady throughout the whole day, but that very heavy rain fell, winds were strong from north-east, and sea rough to boisterous throughout the day. The following gives his observations taken during the day:—

Hour.	Barometer corrected and reduced.	Barometer diurnal variation eliminated.	Wind direction.	Lower Clouds.		State of Sea.	Weather.
				Kind.	Direction.		
	Inches.	Inches.					
Noon.	29·756	29·744	N.-E.	Pk.	N.-E.	Very rough.	Thunderstorm with rain.
0-30 P.M.	·732	·730	N.-E.	Do.	N.-E.	Do.	Continued rain.
1 ,,	·725	·734	N.-E.	Do.	N.-E.	Boisterous.	Ditto.
1-30 ,,	·687	·709	E.-N.-E.	Do.	N.-E.	Do.	Ditto.
2 ,,	·693	·725	E.-N.-E.	Pc.	N.-E.	Do.	Ditto.
2-30 ,,	·679	·718	N.-E.	Do.	N.-E.	Rough.	Ditto.
3-5 ,,	·675	·721	N.-N.-E.	Pc. K.	N.-E.	Do.	Drizzling.
3-30 ,,	·675	·722	N.-E.	Do.	N.-E.	Do.	Continued rain.
4 ,,	·693	·743	N.-N.-E.	Do.	N.-E.	Do.	Drizzling.
4-30 ,,	·700	·745	N.-N.-E.	Pc.	N.-E.	Do.	Ditto.
5 ,,	·712	·752	N.-N.-E.	Do.	N.-E.	Do.	Ditto.
5-30 ,,	·723	·755	N.-E.	Do.	N.-E.	Do.	Ditto.
6 ,,	·730	·752	N.-E.	Do.	N.-E.	Do.	Overcast and squally.
6-30 ,,	·740	·754	N.-E.	Do.	N.-E.	Do.	Drizzling.
8 ,,	·758	·745	N.-E.	Do.	N.-E.	Do.	Ditto.
10 ,,	·766	·734	N.-N.-E.	Pk.	N.-E.	Very rough.	Continued rain.

5·59 inches of rain fell between noon of the 31st and noon of the 1st. The mean velocity of the wind, as registered by the Beckley's anemograph, used in connection with the tidal observations, was 33 miles per hour between 9 A.M. and 6 P.M.

In the preceding table the second column gives the observations at Minicoy corrected for temperature and reduced to sea level and constant gravity. In the third column the pressure data are given after the effect of the ordinary diurnal oscillation has been eliminated, so that the figures in that column represent the changes due to the abnormal features of the weather during the day. These figures show that pressure was fairly steady throughout the day with a slight tendency to rise, and hence apparently indicate that the cyclonic storm was in the initial stage and was developing very slowly. The only feature of importance was the continuous heavy rainfall in the area of disturbance.

The whole of the information hence establishes that winds were variable and light both in the eastern and western quadrants of the depression. They also indicate that weather became more squally during the day, and that very heavy rain was falling at Minicoy and over the neighbouring sea area, and that the area of heavy rainfall increased considerably during the day, more especially in the eastern quadrant. The centre of the depression, so far as can be judged, was between Minicoy and the 8 A.M. position of the *City of Vienna*, and probably in about Lat. 7½° or 8° N. and Long. 74° E.

Probable position of centre of depression and storm.

2nd November. (Chart 2, Plate VI).

November 2nd.—Pressure gave way over the whole of India o the 1st, but the fall was slightly greater at the Malabar Coast station than in the interior of the Peninsula. The depression off the Mal bar Coast hence increased in intensity, as is shown by the followin 8 A.M. observations :—

Station.	Barometer.			Wind.			Temperature.						
	Actual reduced to sea-level and constant gravity.	Change since 8 A.M. previous day.	Variation from normal.	Direction.	Average Velocity in miles per hour.	Percentage ratio of actual to normal velocity.	Maximum.	Variation from normal.	Minimum.	Variation from normal.	Cloud proportion.	Rainfall in past 24 hours.	Weathe
	"	"	"										
Colombo . .	29·876	—·054	+·023	S.-W.	10	167	84 5	?	75·0	?	10	0·22	Sea slight
Trivandrum . .	29·877	—·023	?	N.-N.-W.	4	?	82·5		65·0	?	10	0·81	Showery.
Cochin . . .	29·859	—·040	+·016	Calm.	2	?	87·2	+1·6	74·7	+0·6	10	0·30	
Mangalore . .	29·852	—·064	+·007	E.	2	?	93·8	+7·7	76·4	+2·0	5	*Nil.*	
Minicoy . .	29·753	—·090	?	N.-E.	14	?	80·1	?	76·4	?	10	5·53	Drizzling

General character of weather in the Arabian Sea.

These observations show that the barometer had fallen briskly, an winds strengthened slightly at Minicoy. Winds were, as on th 1st light and somewhat irregular in direction on the Malabar Coast.

The following gives 8 A.M. observations taken on board ve sels in the south-east of the Arabian Sea :—

Name of Vessel.	Position at 8 A.M.		Barometer at 8 A.M.		Wind at 8 A.M.		Weather.
	Latitude. N.	Longitude. E.	Actual.	Corrected and reduced to sea level and constant gravity.	Direction.	Force.	
	° ′	° ′	Inches.	Inches.			
S. S. *Fultala* . . .	5 53	78 59	30·10	29·85	W.-S.-W.	5	Thick weather wi continous rain.
S. S. *Athens* . . .	8 55	72 50	30·06	29·88 ?	Variable.	4	Squally with occ sional showers.
S. S. *Drummond* . .	9 13	67 19	30·15	29·85	E.-N.-E.	4	Fine and clear.
S. S. *Manora* . . .	10 40	65 25	29·95	29·87	N.-E.	4	Passing clouds.
S. S. *Chindwara* . .	At Cali	cut.	29·88	29·85	E.-N.-E.	2	Cloudy.
S. S. *Bohemia* . .	12 25	57 18	30·10	29·99	E.-N.-E.	3	Fine.
S. S. *Inchlonga* . .	16 8	73 7	29·76	29·88	N.-E.	2	Fine.
S. S. *Deccan* . . .	(16 19¾ No	71 23) on.	(29·94) Noon.	29·88	N.-N.-E.	5	Fine.

These vessels all experienced light to moderate north-east wind and fine weather with the one exception of the S. S. *Athens*. Th vessel was about 60 miles due north of Minicoy at 8 A.M. Her bar meter (uncorrected) was apparently steady, but its readings are very doubtful validity. She had squally rainy weather and fre variable winds at that hour. The wind observations of that vess and at the Malabar Coast stations clearly indicate that if a cyclon circulation had been initiated in the depression, it was as yet co fined to a small central area.

Observations of storm taken on board S.S. *Athens* on 2nd November.

The following gives the whole of the weather information for the 2nd contained in her log:—

Hour.	Position.		Barometer.		Wind.		Weather.
	Lat. N.	Long. E.	Actual.	Corrected.	Direction.	Force.	
	° ′	° ′	Inches.	Inches.			
4 A.M.	...	...	...	...	Variable	5	Overcast with occasional rain squalls.
8 A.M.	8 55	72 50	30·06	29·88	Do.	5	Moderate confused sea.
Noon	8 49	73 15	...	...	Do.	5	Heavy showers of rain.
4 P.M.	...	...	...	...	Do.	5	Heavy showers of rain and confused sea.
8 P.M.	...	...	30·06	29·88	Do.	5	Same weather continued.
Midnight	...	...	...	...	Do.	5	Ditto ditto.

The S. S. *Athens* was passing through the northern quadrant of the depression during the day, and was probably not more than 40 miles distant from the centre when nearest to it.

Storm observations taken at Minicoy on 2nd November.

The observer at the tidal observatory, Minicoy, took observations at short intervals during the day. The following gives these observations tabulated in the same form as those of the preceding day:—

Hour.	Barometer corrected and reduced.	Barometer diurnal variation eliminated.	Wind direction.	Lower Clouds.		State of Sea.	Weather.
				Kind.	Direction.		
	Inches.	Inches.					
0-5 A.M.	29·698	29·683	N.-E.	P. K.	N.-E.	Very rough	Drizzling.
7 „	·724	·706	N.-N.-E.	Pc. K.	N.-E.	Boisterous	Squally and overcast.
8 „	·745	·710	N.-E.	Pc.	N.-E.	Do.	Drizzling.
9 „	·754	·709	N.-E.	P. Ck.	N.-N.-E.	Slight	Ditto.
10 „	·743	·700	E.-N.-E.	P.-Ck.	N.-E.	Do.	Overcast.
10-30 „	·723	·688	N.-E.	Pc.	N.-E.	Do.	Ditto.
11 „	·711	·683	N.-E.	Pc.	N.-E.	Rough	Drizzling.
11-30 „	·684	·663	N.-E.	Pk.	N.-E.	Do.	Continued rain.
12 „	·668	·657	N.-E.	Pk.	N.-E.	Do.	Overcast.
1 P.M.	·628	·638	N.-E.	Pk.	N.-E.	Very rough	Continued rain.
2 „	·605	·636	N.-E.	Pk.	N.-E.	Do.	Drizzling.
3 „	·593	·638	N.-E.	Pk.	N.-E.	Do	Continued rain.
4 „	·604	·653	N.-N.-E.	Pk.	N.-E.	Slight	Squally with partial clouds.
5 „	·595	·637	N.-E.	K. Ck.	N.-N -E.	Do.	Drizzling.
6 „	·616	·639	N.-N.-E.	K. Ck.	N.-N.-E.	Do.	Overcast.
8 „	·648	·636	N.-N.-E.	P. Ck.	N.-N.-E.	Do.	Drizzling.
10 „	·664	·633	N.-N.-E.	Pc.	N.-N.-E.	Do.	Lightning and continued rain.
Midnight	·545	·531	N.-E.	Pc.	N.-N.-E.	Very rough	Ditto ditto.

These observations show that pressure decreased slowly but steadily throughout the day up to 10 P.M., when it began to fall very rapidly. It fell rapidly until shortly after midnight, at which hour it was two-tenths of an inch lower than at 10 P.M. of the preceding day. Winds blew strongly from north-east during the day, their velocity averaging slightly above 30 miles per hour.

Inferences from observations.

The observations hence establish that a depression had for between Minicoy and the Malabar Coast during the preceding hours, and that it had intensified during the afternoon of the 2nd. P sure at the centre was probably at least a third of an inch below normal. The centre at midnight was probably advancing very slo in a west by north direction and approaching Minicoy. It is however, possible to give its position exactly or determine its rate motion from the available observations.

3rd November. (Chart I., Plate VII).

November 3rd.—Pressure had increased slightly during the vious 24 hours in the Indian land area. The observations indi that a shallow and somewhat extensive depression lay off the w coast of India from Trivandrum to Karwar. The following g 8 A.M. observations at the coast stations in this area :—

STATION.	BAROMETER.			WIND.		Cloud.	Rainfall in past 24 hours.	WEATI
	8 A.M.	Change in past 24 hours.	Variation from normal.	Direction.	Average velocity in miles per hour.			
	″	″	″					
Colombo . .	29·860	—·016	+ ·004	E.	7	8	1·23	Shower
Trivandrum .	29·849	—·028	?	E.-N.-E.	4	9	0·41	
Cochin . .	29·843	—·016	—·001	S.-E.	2	10	1·85	
Mangalore .	29 838	—·014	—·009	E.-N.-E.	2	4	*Nil.*	
Calicut . .	29·821	—·025	—·029	E.	4	8	0·32	
Karwar . .	29·844	—·032	+ ·007	N.-E.	2	0	*Nil.*	
Minicoy . .	29·711	—·034	?	S.-E.	?	?	?	

Observations at Minicoy on 3rd November.

These observations indicate that the central depression was the west of Minicoy. The following observations were taken Minicoy during the day :—

HOUR.	Barometer corrected and reduced.	Barometer diurnal variation eliminated.	Wind direction.	LOWER CLOUDS		State of Sea.	WEATHER.
				Kind.	Direction.		
	Inches.	Inches.					
4 A.M.	29·541	29·573	S.-S.-E	P. K.	S.-E.	Very rough	Sky clear tow N.-E.
6 "	·640	·645	S.-S.-E.	P. K.	S.-E.	Slight	Squally.
7 "	·686	·668	S.-E.	P. K.	S.-E.	Do.	Ditto.
8 "	·711	·676	S.-E.	Pc.	S.-E.	Do.	Ditto.
9 "	·728	·682	S.-E.	Pc.	S.-E.	Do.	Drizzling.
10 "	·728	·685	S.-E.	Pc. K.	S.-E.	Do.	Ditto.
11 "	·712	·682	S.-S.-E.	Pc.	S. E.	Do.	Squally.
Noon.	·682	·670	S.-S.-E.	Pc.	S. E.	Do.	Ditto.
1 P.M.	·670	·682	S.-S.-E.	Ck.	S.-S.-E.	Do.	Ditto.
2 "	·665	·695	S.-S.-E.	K.	S.-S.-E.	Do.	Dark, gloomy.
4 "	·647	·696	S.-S.-E.	Pk.	S.-E.	Do.	Drizzling.
6 "	·679	·701	S.-S.-E.	Pk.	S.-E.	Do.	Ditto.
8 "	·701	·688	S.-S.-E.	K.	S.-E.	Do.	Dark, gloomy.
10 "	·747	·716	S.-S.-E.	K.	S.-E.	Do.	Drizzling.

Account of storm as experienced at Minicoy.

These observations show that the storm centre advanced w wards to the north of Minicoy, and was nearest to that island betw midnight and 4 A.M. The following brief account of the storm sent by the observer :—"A storm of rain accompanied with fr winds, set in at 9 A.M. on the 1st instant. The wind increased to a gale from noon to 2 P.M., and caused still more rain, which flooded to a depth of 3 to 4 feet the lower parts of the island where almost all the plantations of the islanders are situated. After 2 P.M., the wind was very squally, blowing from north-north-east, north-east, and east-north-east on the evening of the 1st and the 2nd, but changed its direction at 1-30 A.M. on the 3rd instant to south-south-east and south-east. The velocity of wind from 1 A.M. and 2 A.M. was 50 miles and from 2 A.M. to 3 A.M. 58 miles. This storm has caused great loss to the islanders. Many trees fell, and many roofs of houses were blown down, but no lives were lost.

" Many old inhabitants of this island say that they never before experienced a storm so violent, destructive and long-lived as this one on this island. About thirty-five or forty years ago they had a storm, which lasted only for twelve or thirteen hours, and was not severe."

Inference from Minicoy observations.

These remarks indicate that the storm centre was nearest Minicoy about 1-30 A.M. of the 3rd, when the wind shifted suddenly from east-north-east to south-south-east. The strongest winds were those from south-south-east to south-east. The central depression was almost certainly not more than three or four-tenths of an inch in amount. The centre was nearest to Minicoy and probably not more than 10 or 20 miles to the north at 1-30 A.M. of the 3rd. As the island of Minicoy is in Lat. 8° 13′ N and Long. 73° 30′ E., the position of the centre at that hour was about Lat. 8° 20′ N. and Long. 73° 30′ E. The concluding remark indicates that the storm was very exceptional and that cyclonic storms are probably of rare occurrence at Minicoy.

Weather in the Arabian Sea on 3rd November.

The following gives 8 A.M. meteorological data of the south-east of the Arabian Sea for this day, extracted from the logs of vessels :—

NAME OF VESSEL.	POSITION.		BAROMETER.		WIND.		State of Sea.	WEATHER.
	Lat. N.	Long. E.	Actual.	Corrected.	Direction.	Force.		
	° ′	° ′	Inches.	Inches.				
S. S. *Ursa* .	6 43 (noon)	7 89	..	...	E.	...	...	Cloudy.
S. S. *Athens* .	8 5	75 50	30·06	29·88	Variable	4	...	Squalls with occasional showers of rain.
S. S. *Drummond*	8 22	71 21	30·07	29·77	N.-W.	...	...	Heavy rain and thick weather.
S. S. *Manora* .	9 48	70 14	29·88	29·80	Variable	...	...	Wind very unsteady. Rain squalls; fine at intervals.
S. S. *Bohemia* .	11 28	60 47	30·05	29·94	E.-N.-E.	2	...	Cloudy.
S. S. *Inchlonga*	13 16	74 27	...	...	S.-E.	4	...	Do.
S. S. *Deccan* .	13 17	69 46	29·89	29·83	N.	5	Moderate	Fine.

The data contained in the preceding table indicate that weather w squally and showery in the Arabian Sea off the Travancore and W Ceylon coasts. The winds, as observed on board the S. S. *Mano* and *Athens* in this part of the Arabian Sea, were variable and moder in force, thus indicating that the storm was of small extent, and p bably of moderate intensity. The only vessel near the storm a during the day was the S S. *Drummond.* The following gives t whole of the available information contained in her log :—

HOUR.	POSITION.		BAROMETER.		WIND.		State of Sea.	WEATHE
	Lat. N.	Long. E.	Actual.	Reduced.	Direction.	Force.		
	° ′	° ′	Inche	nches.				
4 A.M. . .	...	...	30·07	29·77	N.-E.	2	...	Heavy r and lig ning.
8 „ . .	8 22	71 21	.07	·77	N.-W.	...	...	Heavy r and thi weather
Noon . .	8 14	72 0	·07	·77	W.	5	...	Do. do.
4 P. M. . .	...	...	29·98	·68	S.-W.	5	...	Showery.
8 „ . .	...	...	30·05	·75	S.-S.-W.	5	...	Weather clearing
Midnight . .	...	...	·08	·78	S.-S.-E.	4	Moderate.	Fine and clear.

Weather conditions off the Malabar and Konkan coasts from 3rd to 8th.

During the next five days, *i.e.*, from the 3rd to the 8th, weather w slightly disturbed and squally off the Malabar and Konkan coas How far this was a residual effect of the storm described in the pr ceding paragraph, or how far it was due to the increased strength the south-west winds at the entrance to the Bay, and hence also pr bably in the Arabian Sea to the west of Ceylon, can only be conjec ured in the absence of complete meteorological data. The latte however, appears to be the most probable cause.

The following summary of the Minicoy observations indicat clearly the character of the weather during this period off the Malab Coast :—

DATE.	BAROMETER.		WIND.		CLOUD.	RAINFA
	8 A. M.	Change in past 24 hours.	Direction 8 A.M.	Average velocity of 24 hours preceding 8 A. M.	8 A. M.	24 hour precedi 8 A.M
	Inches.	Inch.				
3rd	29·720	-- ·027	S.-E.	33	8	4·01
4th	·765	+ ·045	E.-S.-E.	14	8	0·32
5th	·794	+ ·029	S.	28	4	1·25
6th	·830	+ ·036	S.-W.	15	4	0·20
7th	·866	+ ·036	S.-W.	14	2	*Nil.*
8th . . .	·904	+ ·038	S.-W.	4	3	*Nil.*
9th	·910	+ ·008	N.	2	3	*Nil.*

These observations establish that pressure increased slowly an steadily from the 3rd to the 9th, and that strong southerly winds pr vailed from the 3rd until the 7th. Winds fell off very rapidly in strength on the 8th, and shifted from south-west on that day to north on the 9th. Northerly winds were recorded on 19 days out of the remaining 22 days of the month. These observations hence indicate that north-east monsoon conditions were established as far south as Minicoy (Lat. 8° N.) on and from the 9th of November.

Rainfall data of west coast stations from the 3rd to 9th November.

Weather was showery during this interval in Malabar and Canara. The following gives a return of the daily rainfall from the 3rd to the 9th, recorded at the meteorological observatories in these coast districts :—

STATION.	AMOUNT OF RAINFALL ON—						
	3rd.	4th.	5th.	6th.	7th.	8th.	9th.
	Inches	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Colombo	1·23	0·02	*Nil.*	*Nil.*	*Nil.*	*Nil.*	1·53
Trivandrum	0·41	*Nil.*	0·03	0·07	0·28	*Nil.*	0·22
Cochin	1·85	*Nil.*	*Nil.*	0·03	*Nil.*	*Nil.*	*Nil.*
Mangalore	*Nil.*	*Nil.*	*Nil.*	0·10	0·33	0·03	0·14
Calicut	0·32	*Nil.*	*Nil.*	1·91	0·28	*Nil.*	*Nil.*
Karwar	*Nil.*	*Nil.*	*Nil.*	*Nil.*	0·09	0·02	*Nil.*
Mormugao	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Ratnagiri	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*

The rainfall data shew that the showery weather extended as far north as Karwar, and lasted until the 9th, after which fine dry weather set in over the Konkan and North Canara districts. Occasional showers continued to be received in Malabar and Travancore.

Cloud data of west coast stations from the 3rd to 9th November.

The following table gives the cloud amount as registered at 8 A.M. at the observing stations on the west coast. It shews clearly that weather was fine with partial cloud throughout this period :—

STATION.	AMOUNT OF CLOUD AT 8 A. M. OF—						
	3rd.	4th.	5th.	6th.	7th.	8th.	9th.
Colombo	8	5	5	4	1	0	3
Trivandrum	9	3	9	8	0	0	4
Cochin	10	6	3	0	0	0	0
Mangalore	4	0	6	10	10	5	7
Calicut	8	2	9	10	0	10	6
Karwar	0	0	1	4	8	4	2
Mormugao	0	0	3	4	10	3	1
Ratnagiri	0	0	3	4	1	4	1

The wind data furnish similar evidence of the fact that, although the coast observations indicated the existence of a shallow depression (as on the 2nd and 3rd), weather was fine with partial cloud, light to moderate winds and occasional showers, but was not, according to the ordinary acceptation of the word, stormy.

The following gives the probable positions of the centre of storm from the 1st to the 3rd:—

Date.	Hour.	POSITION OF CENTRE.		Distance passed over.	Av hc vel
		Latitude N.	Longitude E.		
1st	8 A.M.	8° 0′	73°50′	...	
2nd	„	8° 0′	73°20′	43	
3rd	„	8°15′	72°45′	30	

The storm hence drifted very slowly westwards during period at an average rate of 2 miles per hour, and passed on the into an area for which there are no data. It probably continue advance in the same direction for some days afterwards slowly ing up whilst advancing westwards. The southerly humid wind the eastern quadrant extended northwards along the Malabar Konkan coasts on the 4th and 5th and gave showery weather thunderstorms. The Minicoy observations appear to indicate these conditions continued until the 6th, by which date the dep sion had probably filled up. The southerly winds then fell off rap in strength on the 7th and 8th and were replaced by northerly w on the 9th, on which day normal north-east monsoon conditions tained over the Arabian Sea.

CHAPTER IV.

PORT BLAIR CYCLONE OF 31ST OCTOBER TO THE 7TH NOVEMBER.

Origin of cyclone in the Gulf of Siam.

The conditions and circumstances of the origin of the cyclone under discussion are as yet unknown. It crossed the Gulf of Siam on the 30th and 31st of October, and it appears probable that it originated in that sea area.

Storm originated in Gulf of Siam and not in China Sea.

Dr. Doberck, Director of the Hong Kong Observatory, in reply to an enquiry, states that no bad weather was reported in the China Sea from the 23rd of September to the 12th of November. He also adds that he has come across only one case of a small cyclone which originated in the Gulf of Siam and advanced westwards, probably across the Malayan Peninsula. Fairly complete information has been obtained of the character and path of the storm across the Gulf of Siam and the Malayan Peninsula.

The following account of the storm extracted from the *Siam Free Press* was forwarded by the Port Officer, Rangoon :—

Account of storm in the Gulf of Siam and Lower Siam in *Siam Free Press.*

> "A cyclone swept over the Gulf of Siam on the 30th and 31st of October. It passed in its course over the island of Koh Samuie at the entrance to the Bight of Bandon and entirely destroyed the towns of Bandon and Chaiya, the latter place being one of the largest towns on the Gulf. Five thousand six hundred and sixty houses were blown down, trees between 4 or 6 feet in diameter were uprooted or snapped in two by the force of the wind, and there was a heavy loss of life. The whole country in the track of the storm is a complete desert without a tree or house standing. There also appears to have been heavy loss at sea, as the S.S. *Cape Clear,* bound from Champon to Chaiya, passed large quantities of wreckage, such as junks cargo, and dead bodies. The S.S. *Rainbow* capsized at Koh Samuie, and the officers and crew of 30 men and 3 passengers were all lost, with the exception of 6 natives. The storm lasted about six hours, and is said to be one of the most destructive which has ever visited the Gulf of Siam."

Account of storm in Lower Siam by the Bangkok Foreign Office.

The following account of the storm was received from the Bangkok Foreign Office through A. A. Apcar, Esq., Consul General for Siam at Calcutta, and is stated to have been drawn up from the reports of the Governors of Chaiya and Renong :—

> "It appears that the storm broke out in Chaiya on the 31st October at 11 P.M., and lasted with unabated force up to 3 A.M. on the 1st November. The land was covered with water up to 7 or 8 feet and 387 religious buildings, and 4,238 other buildings, amongst which were the telegraph station and the court-house, were more or less destroyed. All telegraph poles were broken, 76 persons died through the sea water rushing up to the houses, and 33 persons died through the fallen timber.
>
> "The report of the Governor of Renong states that the storm commenced on the 1st November at 1 A.M. Rain was falling and the wind was blowing from the north-east, and the sky presented a fiery red appearance at sunset of the 31st. Many trees were uprooted on the hills surrounding Renong and the water to the

north side of the Kapo Creek was dry for about six hours. The storm raged throughout the province up to about 7 A.M., and during that time severe damage was done to some parts of the palace, and on the court-house on the west side the corrugated-iron roof was blown down.

"In the district of Renong itself 42 houses were blown down and 3 persons were killed, and so in other places; the greatest damage was done in the village of Kapo, where 122 houses were blown down and 5 houses destroyed through the water rushing in. Work had to be stopped at 31 mines, and roads were destroyed inland throughout the district. On the surrounding islands the storm was felt from the Island Koh Sang and Song (British territory) to Koh Hartsai Yas, Koh Xang, Koh Phayam, Koh Klang, Koh Bangchak, Koh Klang Kas (Renong), and Koh Rakam (Takuapa) to St. Matthew's Island and Chance Island. Little damage was done to Koh Song and Koh Rakam. The storm was not felt from Koh Phi Pakuam (Renong) following the course of the Kra up to Kraburi."

From the foregoing report it appears that this storm travelled at the rate of 18 miles an hour.

According to the account of the survivors of the S.S. *Rainbow*, which was at anchor about a quarter of a mile to the south-east of the island of Koh Samuie, the weather which had previously been very fine became threatening on the evening of the 31st, and at 10 P.M. the wind freshened rapidly. The captain at 11 P.M. ordered the fires to be lighted. The wind and sea increased very rapidly at this time, and the vessel rolled heavily. Very shortly afterwards (between 11 P.M. and midnight) a heavy squall struck the vessel, when she gave one heavy roll to port, capsized, and sank.

Storm passed over St. Matthew's Island.

The storm centre also appears to have passed over, or very near to, St. Matthew's Island, in the Andaman Sea, Lat. 10° N. and Long 98¼° E., and about 30 miles to the west of the mouth of the Pakshan River, and 100 miles to the west-north-west of Chaiya. The captain of the S. S. *Fitzpatrick*, when passing near the island in the second week of November, noticed that many of the huge trees of that island had been very recently uprooted. Many trees were quite bare of leaves, and the whole of the foliage of the island had the appearance of having been scorched by fire.

The preceding information hence appears to establish conclusively that the storm originated in the Gulf of Siam, probably in about Lat. 9° N. and between Long. 102° to 103° E., and also that it was unique in its origin and its earlier features.

The following gives a brief description of the part of the Malayan Peninsula (Lower Siam) traversed by the storm :—

Brief description of the portion of the Malayan Peninsula included in

The long and narrow peninsula, which stretches southwards between the Andaman Sea and Straits of Malacca on the west and the Gulf of Siam and South China Sea on the east, extends from Lat. 14° N. to Lat. 1° N. It is divided into two portions by the Isthmus of Kra (in Lat. 10° N.). The southern portion is usually called the Malayan Peninsula. Both portions are more or less mountainous. The mountains in each portion consist of a central range, which runs the track of the storm. (Plate XV.)

approximately north and south, and forms the backbone of the country, with numerous lateral offshoots. The Isthmus of Kra is a well-marked break in this central range of hills, and is stated to be in its highest part not more than 100 feet high. The hills also immediately to the north and south of the isthmus appear to occur chiefly as isolated elevations, and not as continuous ranges. The isthmus is so low that it has been proposed to construct a canal across it, and thus shorten very considerably the sea passage between Calcutta and the Burma ports and China, but the estimated cost is prohibitive. The part of the peninsula crossed by the storm hence appears to consist of comparatively low ground, interrupted by isolated hills of moderate elevation. The east coast of the peninsula, to the south of the Isthmus of Kra, curves through south to east, and encloses a small gulf known as the Bight of Bandon. The town of Bandon is on the south coast of this Bight in Lat. 8° 55′ N. and Long. 99°38′ E. and the town of Chaiya on the west coast of the Bight is in Lat. 9°24′ N. and Long. 99°36′ E. The town of Renong is on the opposite side of the peninsula near the entrance to the Pakshan River, which forms the boundary between Tenasserim and the province of Renong in Siam. It is in Lat. 9°56′ N., Long. 98°42′ E.

The course of the cyclone hence directed it to that part of the peninsula where the land surface offered the least resistance to its passage.

Summary of chief facts respecting track and motion of the storm in the Gulf of Siam and Lowor Siam.

The typhoon or cyclone at this stage was one of great intensity, and accompanied with violent and destructive hurricane winds when crossing the Malayan Peninsula. The duration of the storm is given by the Siam Foreign Office as four hours, and is probably that of the time it took the inner storm area (in which winds were of force 9 to 12) to pass over places in the track of the centre. As the rate of advance of the storm at this stage was nearly 19 miles an hour, the diameter of the typhoon proper or inner storm area of the cyclonic disturbance along the direction of its advance was probably between 70 and 80 miles. This gives the diameter of the storm area in an east and west direction.

The account of the storm obtained from the Bangkok Foreign Office shows that the centre very probably passed over the town of Chaiya and the village of Kapu. The belt of destructive winds is not very clearly indicated by that statement. It apparently included Renong to the north of the centre, but did not extend so far south as the town of Tapuapa. This shows that the breadth of the area of destructive winds just before passing out of the Malayan Peninsula was less than 60 miles. It is hence probable that the shape of the storm area as defined either by the isobars or the area of destructive winds was oval or elliptical, the greatest diameter of which was approximately in the direction of the track of the centre. The storm area was hence probably at this stage, as it was undoubtedly when crossing the Andaman Sea and Bay of Bengal, elliptical-shaped, with its longest diameter in the direction of advance, the longest diameter be about 80 miles and the shortest 60 miles.

The preceding information also shows clearly that the storm vanced across the Gulf of Siam in a westerly or west-north-west direction on the 30th and 31st of October, and reached the east coa the Malayan Peninsula in the districts of Chaiya and Bandon in Lo Siam about midnight of the 31st. The centre passed over the t of Chaiya about 2 A.M. of the 1st. It reached Port Blair about A.M. of the 2nd. Assuming these data as approximately exact, storm during this period of 24½ hours travelled about 460 miles an average velocity of between 18½ and 19 miles per hour.

The following are the more important inferences respecting track and character of the storm at this stage based upon the ceding statement:—

(1) The centre passed to the south of Koh Samuie (in 9° 30′ N. and Long. 100° E.) at midnight. The *Rainbow*, it is stated, had easterly winds before she sa

(2) The centre passed over Chaiya (Lat. 9° 12½′ N. and Lo 99° 36′ E.) about 1-30 A.M. or 2 A.M. The storm appear have raised a considerable storm wave, as it is stated the land was covered with water to a depth of 7 or 8 f and that 76 persons died through the water rushing into the houses. The destruction of life and property Chaiya was probably due in large part to the storm wa

(3) The storm centre passed nearest to Renong about 3 A. and a little to the south of that town. It probably pas centrically over the village of Kapu in the Renong I trict.

(4) The storm centre probably also advanced a little to south of St. Matthew's Island.

(5) The direction of advance of the storm at this stage west-north-west or more exactly N. 69° W.

(6) The rate of advance of the storm at this stage was so what greater than 18 miles per hour, but probably did exceed 20 miles per hour.

(7) The inner storm area in which winds were of force 9 or to 12 was probably elliptical-shaped, and the long diameter, running approximately east and west, was ab 80 miles in length, and the shortest (lying north and sou 60 miles in length.

It is very probable that the storm was an example of the cl known as typhoons in the China Sea. It was quickly generated, the conditions being favourable to that rapid accumulation of action in a comparatively small space which invariably accompanies concentrated torrential rain.

November 1st.—The storm under discussion, the origin of which has been traced to the Gulf of Siam, entered the Indian area early on the morning of the 1st, and formed the chief feature of the meteorology of the weather in India during the next week.

The abnormal pressure conditions prevailing in the Indian area at this time have been fully stated in a previous section. Pressure was very considerably above the normal on the 31st, but was beginning to give way over nearly the whole of India. The changes were however small and the pressure distribution in the Indian land area on the morning of the 1st was similar to that of the 31st October. The chief features were—

Chief features of meteorology of India on 1st November. (Plate VIII).

(1) Pressure was in excess over the whole of India by amounts averaging very nearly a tenth of an inch.

(2) Pressure was most largely in excess in the area stretching from the South Deccan and Circars to Bihar and the North-Western Provinces. That area was hence one of local excess of pressure.

(3) The excess of pressure was least in amount in Lower Burma and the south of the Bay and off the Malabar coast. The cyclone was entering this area of local deficiency of pressure in the Andaman Sea, and was hence intensifying the deficiency.

Pressure was very uniform over North-Western and Central India. Steepish gradients obtained in the peninsula and the north of the Bay. In the Bay (excluding the Andaman Sea) winds were slightly stronger in the northern half of the Bay than in the southern half. They ranged in force from 4 in the north of the Bay to 2 and 3 in the centre and south of the Bay.

The mean or normal force of the winds at the entrance to the Bay in November is 2·5 and winds are variable in direction, but south-west winds slightly predominate. In the Andaman Sea they are of average force 3, and in the north-west angle of the Bay they average slightly less than 2. They hence usually increase in force south-westwards from the head of the Bay and westwards from the Andaman Sea to the Coromandel and East Ceylon coasts (*i. e.*, from Lat. 8° N. to 16° N.), where they slightly exceed 4 in force.

Winds on the 1st were hence strongest in that part of the Bay where they are usually weakest in November, and *vice versâ*. They were, however, in general accordance with the abnormal pressure distribution of the day.

It may also be noted that the changes of pressure during previous 24 hours in the Indian area were everywhere smal amount, and left the distribution of pressure and its variations f the normal unchanged.

The following table gives data :—

PROVINCE.	PRESSURE.		Pressu anoma
	Change since 8 A.M. of previous day.	Variation from normal.	
	Inch.	Inch.	Inch
Burma	−·016	+·062	−·0
Bengal and Assam	−·006	+·119	+·0
North-Western Provinces	−·004	+·126	+·0
Punjab	−·013	+·110	+·c
Bombay	+·001	+·087	−·0
Central Provinces	−·013	+·122	+·0
Guzerat and Central India	0	+·110	+·0
Sind and Rajputana	0	+·109	+·0
Madras	−·009	+·090	− 0

Assuming that the storm centre passed over Chaiya between 1 A.M. and 2 A.M., and that it was travelling on a straight course v an average velocity of 18½ miles per hour, its position at 8 of the 1st would be in Lat. 9° 50′ N. and Long. 97° 30′ E. T agrees satisfactorily with the land and marine 8 A.M. meteo logical data of the day.

Weather in the Bay of Bengal.

The following gives a summary of the observations taken on b vessels in the Bay of Bengal at 8 A.M. :—

SHIP.	POSITION.				BAROMETER.		WIND		State of sea.	Weath
	Latitude N.		Longitude E.		Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.		
	°	′	°	′	Inches.	Inches.				
S. *Glenricht* .	4	30	92	15	...	...	W.	2	...	Fine.
S. *Eurydice* .	4	45	92	40	...	...	S.-W.	4	...	Squally.
S. *Loudon Hill*	5	32	93	18	30·20	29·92	Calm	0	...	Calms and variable
S.S. *Stella* .	5	40	83	0	30·02	29·93	Variable	...	...	Cloudy.
S.S. *Pundua*	6	56	92	39	30·09	29·92	Calm	0	...	Cloudy.
S. *Joseph* .	6	5	93	0	30·02?	29·92	Variable	1	Sea like glass.	Light air calms;sq appeara in eveni
S. *Bann* .	11	13	90	25	...	...	N.-E.	4	...	Squally.

SHIP.	POSITION.		BAROMETER.		WIND			
	Latitude N.	Longitude E.	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.	State of a.	Weather.
	° ′	° ′	Inches.	Inches				
S. *Lena* .	11 12	89 45	...	...	Variable	1	...	Cloudy. Squally during part of day.
S. S. *Lincolnshire.*	11 2	84 19	30·00	29·90	N.-E.	4	Light head.	Fine and clear.
S.S. *Waverley*	Masulipatam		...	...	N.-E.	5	Moderate	Clear.
S.S. *Colaba* .	18 05	91 28	30·01	29·94	N.-N.-E.	2	...	Fine.
S. *Anne Main*	19 15	90 30	29·92	29·98	N.-E. by N.	4	Smooth	Fine and clear.
S.S. *Sirsa* .	19 35	86 38	30·11	30·00	N. by E.	4	...	Fine. Light to moderate breeze during day.
S.S. *Ganges* .	19 40	86 30	30·13	29·99	N.-E.	4	...	Fine and clear.
S.S. *Tasmania*	20 40	87 40	30·13	30·00	N.-E.	2	...	Fine.
S. *Charles Dickens.*	20 53	88 07	29·87	30·00	N.-E.	3 to 4	...	......
S.S. *Pallamcotta.*	21 15	88 30	30·15	30·01	N.	3	...	Fine and clear.
F.L.V. *Canopus.*	Intermediate Station.		...	...	N.-E.	4	Moderate swell from south.	Clear.
S.S. *Arratoon Apcar.*	Calcutta		...	...	N.-E.	2	...	Fine.

The preceding data show that winds were even lighter and more variable at the entrance to the Bay than is usual in November.

The S. *Eurydice* in Lat. 4° 45′ N. and Long. 92° 40′ E. had moderate south-west winds and occasional squalls. Five vessels in addition to the S. *Eurydice* were between Lat. 4° N. and 8° N. All had light airs and calms in the morning with a smooth sea. Fine clear weather obtained over the remainder of the Bay. Winds were somewhat stronger than their mean force in November, and ranged from 2 and 3 at the head of the Bay to 4 and 5 on the Coromandel and Madras coasts. It has already been stated that the storm entered the Andaman Sea very early on the morning of the 1st, and that the centre passed to the south of St. Matthew's Island between 4 and 5 A.M. The following observations taken at the

Weather in the Andaman Sea on 1st November.

nearest land observatories show to what extent the storm was inf encing the meteorology of the Indian area at 8 A.M. of the 1st—

STATION.	BAROMETER.			WIND			TEMPERATURE DURING PREVIOUS 24 HOURS.				Cloud proportion.	Rainfall
	Actual reduced to sea-level and constant gravity.	Change since 8 A.M. previous day.	Variation from normal.	Direction.	Average velocity in miles per hour.	Percentage ratio of actual to normal velocity.	Maximum.	Variation from normal.	Minimum.	Variation from normal.		
	″	″	″				°		°			
Mergui .	29·889	—·039	?	N.-N.-W.	2	001	88·2	?	67·7	?	10	0
Tavoy .	·911	—·021	?	Calm	2	?	89·7	?	76·2	?	10	[illegible]
Moulmein	·923	—·039	+0.41	N.-N.-W.	3	?	91·5	+3·4	77·8	+4·8	1	[illegible]
Diamond Island.	·918	—·032	+·035	N.-N.-E.	5	63	89·3	+2·91	74·5	—1·9	7	[illegible]
Port Blair	·863	—·036	?	N.	5	84	89·4	?	78·1	...	8	0·
Nancowry	·918	—·051	?	Calm	...	...	86·1	...	76·2	...	10	0·

These observations give no indication of the existence of a cyclo in the Andaman Sea. The barometer had fallen slightly, but w still above the normal of the day. Winds were light, and blowi from some northerly point at all stations, and were generally belo their normal strength. These observations show that the storm w of small extent, and that it was not due to the gradual developme of a disturbance in the Andaman Sea.

The following gives a statement of 8 A.M. observations taken board vessels in the Andaman Sea on the 1st:—

SHIP.	POSITION.		BAROMETER.		WIND		Weather.
	Latitude N.	Longitude E.	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.	
	° ′	° ′	Inches	Inches.			
S. *Marpesia* .	?	?	30·10	29·85	N.-E.	2	Passing showers.
S.S. *Japan* .	7 40	98 10	30·09	28·90	W.-N.-W.	4	Overcast; light rai squally.
S.S. *St. Regulus* .	11 28	95 40	...	...	N.-E.	6	Heavy squalls.
S.S. *Nevasa* .	14 10	96 45	29·99	29·90	E.-N.-E.	4	*Morning*—fin *Evening*—win increased to g with rain.
S.S. *Chanda* .	15 20	95 35	30·16	29·92	Variable	2	Cloudy and fine.
S.S. *Mayo* .	Rangoon		29·90	29·93	N.	2	Fine and clear.
S.S. *Shahjahan* .			...	...	N -E.	4	
S.S. *Patna* .			29·88	29·93	N.-E.	1 to 2	Fine.

The weather in the Andaman Sea at 8 A.M. of the 1st was, judging only from the data given in the two preceding tables, fine, with light to moderate winds. Several vessels which were near the Lower Pegu coast during the day had fine clear weather throughout. The only vessel which experienced strong winds and squally weather at 8 A.M. was the S.S. *St. Regulus.*

The only vessel which encountered the force of the storm on the 1st was the S. *Marpesia* which was proceeding to Rangoon. The following gives the whole of the information relating to the storm contained in the abstract of her log forwarded by the Port Officer, Rangoon :—

DATE AND HOUR.	Barometer. uncorrected	WIND		State of sea.	Weather.
		Direction.	Force.		
	Inches.				
1st—					
Noon	30·10	N.-E.	2	...	Passing showers.
1 P.M.	...	...	...	...	Squally.
3 P.M.	...	...	4	...	Wind suddenly increased at 3 P.M., carrying away jib-boom and fore-top-mast head.
4 P.M.	29·95	N.-E.	Hard gale	...	......
6 P.M.	Falling rapidly.	...	Wind increasing.	High	Constant rain.
9 P.M.	29·40	...	Hurricane.	...	Wind blew away fore and main topsails and fore topmast stay-sail.
Midnight	29·10	N.	Hurricane force.	...	Constant rain.
2nd—					
2 A.M.	29·20	N.-W.	Ditto	...	......
4 A.M.	29·70	W.	Wind moderate.	...	Sky overcast.
6 A.M.	29·80	S.-W.	...	...	......
8 A.M.	29·90	S.	6	...	Constant rain.
Noon	30·00	S.-E.	4	...	Sky overcast.

The Port Officer, Rangoon, who obtained this information, states that it is not a copy of the log, as that was not written up in consequence of the mate's leg having been broken during the storm. It is a copy of the Master's notes. The position assigned by the Captain to the vessel at noon is Lat. 9° 12′ N. and Long 96° 19′ E. This is, however, almost certainly wrong, and her position was probably in about Lat. 11½° N. to 12° N. and Long. 94° E. No information is given as to her course. It is, however, probable that she was proceeding in a north-westerly course, and also that she was carried to the west during the afternoon by the winds and currents set up by the storm in the centre of the Andaman Sea. She was during the evening of the 1st in the west quadrant, and thence passed into the southern and eastern quadrants. She was nearest to the centre between midnight a A.M. of the 2nd, and probably very shortly after midnight. As centre passed over Port Blair between 2 and 3 A.M. of the 2nd, S. *Marpesia* could have been not more than 20 or 25 miles tc south-east of that port when she was nearest to the storm centre. corrected reading of her barometer at midnight was 28·85," at wl hour the centre was probably not more than 10 or 15 miles to east-north-east.

The S.S. *Japan* and S. S. *St. Regulus* experienced squally weat during the afternoon. The S.S. *St. Regulus* in Lat. 12° N. and Lc 96° E. at noon and proceeding on a north-west course at the rat 10 knots had a fresh east-north-east breeze and squally weather the morning, and strong east winds and heavy squalls during afternoon and evening. She was from 150 miles to 200 miles d tant from the storm centre during this period.

The S.S. *Japan* was in Lat. 8° N. and Long. 98° E. at noon a proceeding in a north-north-west course. She had fresh to stro breezes during the afternoon and evening, but shortly after midni the wind shifted to south-south-east, and blew for some hours in ha squalls with continuous drizzling rain. She was then about 200 mi to the south-south-east of the centre.

2nd November. (Plate IX.)

November 2nd.—The decrease of pressure which had commenc on the 31st continued on the 1st. The changes were small and l than ·05," except in the greater part of the Bay and the adjace coasts (except Tenasserim). The following table gives data showi the character of the changes and of the pressure distribution various parts of India:—

PROVINCE.	PRESSURE.		Anomaly
	Average change in past 24 hours.	Variation of average actual pressure from normal.	
	Inch.	Inch.	Inch.
Burma	—·054	0	—·064
Bengal and Assam	—·048	+·067	+ 003
North-Western Provinces and Oudh	—·030	+·094	+·030
Punjab	—·011	+·095	+·031
Sind and Rajputana	—·040	+·071	+·007
Guzerat and Central India	—·028	+·082	+·018
Central Provinces	—·044	+·078	+·014
Bombay	—·041	+·046	—·018
Madras	—·056	+·049	—·015
Whole of India	—·039	+·064	

Skies were clear and weather fine over the whole of India except in Lower Burma and Southern India, where they were heavily clouded. The peninsula south of Lat. 15° N. received general light to moderate rain. The land observations show that there were two depressions influencing the weather in the Indian area. These were (1st) a shallow depression off the Malabar coast, and (2nd) a depression in the centre of the Bay of Bengal, the character of which was only faintly indicated by the land observations.

The following gives 8 A M. data of the land stations nearest to the storm at that time:—

STATION.	BAROMETER.			WIND.			TEMPERATURE.					
	Actual reduced to sea-level and constant gravity.	Change since 8 A.M. previous day.	Variation from normal.	Direction.	Average velocity in miles per hour.	Percentage ratio of actual to normal velocity.	Maximum.	Variation from normal.	Minimum.	Variation from normal.	Cloud proportion.	Rainfall in past 24 hours.
	"	"	"				°		°			
Nancowry .	29·865	—·053	...	Calm .	...	?	82·0	?	75·1	?	10	0·44
Port Blair .	·714	—·149	?	? Wind-vane broken.	Anemometer broken.	?	78·8	?	70·0	?	10	3·90
Diamond Island.	·838	—·080	—·043	E.-N.-E.	13	163	88·3	+1·8	75·0	—1·3	10	*Nil*
Masulipatam	·922	—·055	+·071	N.-N.-E.	6	?	89·5	+5·5	73·1	—1·2	2	*Nil*

The cyclone passed over Port Blair between 2 and 3 A.M. of the 1st, and then crossed out from the Andaman Sea into the Bay of Bengal. Assuming that its direction and rate were the same on the morning of the 2nd as on the 1st, a supposition which it will be seen is confirmed by the marine data, the centre at 8 A.M. would be in Lat. 12° 10′ N. and Long. 91° 10′ E.

Weather in the Bay of Bengal.

The following table gives 8 A.M. data of the Bay of Bengal, extracted from the logs of vessels navigating the Bay at this time :—

Ship.	Position.				Barometer.		Wind.		State of sea.	Weather.
	Latitude N.		Longitude E.		Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.		
	°	'	°	'	Inches.	Inches				
S. *Glenricht* .	5	45	92	20	...	...	W.	3	...	Showery.
S. S. *Stella* .	5	54	86	15	29·96	29·87	N.-W.	4	...	Cloudy. *Evening*—rain, with squalls.
S. S. *City of Vienna.*	6	0	79	20	29·87	29·87	Variable	2	Moderate	Frequent squalls and rain in morning.
S. *Eurydice* .	6	10	92	40	. .	...	S.-W.	4	...	Squally; dusky sky. *Morning*—heavy squalls.
S. *Loudon Hill*	6	25	93	15	30·20	29·92	Variable	...	...	Calm and light variable airs. Cloudy with showers in afternoon.
S. S. *Plassey*	7	0	82	0	29·58	29·85	W.-S.-W.	4	...	Cloudy.
S. *Joseph* .	7	45	92	10	29·80 ?	29·86	S.-W.	5	...	Squally; showery. Heavy rain in afternoon.
S. S *Pundua*	8	6	87	58	30·04	29·87	W.	4	...	Cloudy.
I. M. S. *Clive*	Madras				29·94	29·88	N.-E.	4 to 5	N.-E. swell.	
S. *Bann* .	12	10	90	15	...	...	N.-E.byE.	4	...	Very threatening appearance to north. Light unsteady breeze.
S. *Kalakana* .	(13	15	88	33) noon.	29·76	29·86 ?	N.-N.-E.	...	...	......
S. *Lena* .	13	40	89	0	...	...	N.-E.	4	Fresh swell in evening.	Squalls in morning. Heavy rain.
S. S. *Lincolnshire.*	15	15	85	15	29·96	29·87	N.-E.	5	Considerable sea.	......
S. S. *Chanda*	17	45	91	40	30·10	29·88	N.-N.-E.	5	...	Cloudy.
S. S. *Palamcotta.*	18	0	91	25	30·03	29·89	N.-E.	4	...	Fine in morning. Squalls and rain in afternoon and evening.
Barque Lady Agnes.	(18	57	87	30) noon.	...	...	N.-E.	6	...	Cloudy.
S. S. *Loodiana*	19	0	86	20	30·05	29·95	N.-W.	4	Smooth .	Fine and clear in morning.
S. *Meanatchy*	Gopalpur.				30·06 ?	...	N.-E.	...	...	Fine and clear.
S. *Anne Main*	19	50	90	24	29·84	29·91 ?	N.-N.-E.	...	...	Slight rain in evening.
S. S. *Colaba* .	20	34	88	43	30·04	29·97	N.-N.-E.	4	...	Fine.
S. S. *Ganges*	Near Sandheads.				30·15	30·01	N.	3	...	
F. L. V. *Canopus.*	Intermediate station.				30·01	29·99	N.	4	Slight swell.	
F. L. V. *Star.*	Lower Gasper station.				29·99	29·99	N.-E.	3	Smooth .	Calm in evening.
Waverley .	Near Coconada (5° S.-W.)				...	...	N.-E.	5	...	Clear.

The preceding data show that no change had as yet occurred in the north of the Bay. Fine clear weather, with moderate north-east winds, obtained over the whole area to the north of Lat. 18° N. Winds were of average force 4·1 as compared with 3·5, the norma force in November. The northward extension of squally weather was shown by the fact that the vessels between Lat. 8° N. and 20° N. and to the east of Long. 88° E. had cloudy weather with occasional showers and squalls in the afternoon and evening.

Weather in the south of the Bay had changed considerably during the previous 24 hours and was now squally with much rain and with moderate south-west to west winds. The mean force of the winds experienced by seven vessels to the south of Lat. 8° N. in the morning was 3·7, whereas on the morning of the 1st the average force was only 2·0. The data hence show clearly that moderate south-west winds prevailed in the south of the Bay, where on the 1st and preceding days calms and light and variable airs had obtained. The weather was also more or less squally, and the squalls increased in severity during the day. The data are not sufficient to show clearly how far these winds extended up the south-east of the Bay, as there is no information available for the area between Lat. 8° N. and 11° N. It is, however, very probable from the rapid changes in the winds and weather that this extension was due to the action of the storm, and that the humid south-west winds of the south of the Bay now extended northwards as far as Lat. 12° N. in the south-east of the Bay, and were feeding into the storm. These rapid changes are, it may here be remarked, a strong indication that the storm was one of comparatively low elevation and that the centre of greatest activity was probably not more than 4,000 or 5,000 feet above the sea surface. The intense indraught to the vortex drew into it all the available supplies of aqueous vapour in the lower atmosphere, due not only to evaporation in the Bay area, but also to those of the equatorial belt to the south of the Bay.

Weather in the Andaman Sea.

The following gives a summary of the 8 A.M. observations taken on board ships in the Andaman sea on the 2nd :—

NAME OF VESSEL.	POSITION.		BAROMETER.		WIND		State of sea.	Weather.
	Latitude N.	Longitude E.	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.		
	° ′	° ′	Inches.	Inches.				
S. S. *Nevasa*.	11 10	96 55	29·77	29·68	N.-E.	4	...	Fine and cloudy.
S. S. *Japan* .	11 30	95 30	30·06	29·86	E.-S.-E.	5	Moderate.	Squalls during day.

NAME OF VESSEL.	POSITION.		BAROMETER.		WIND.		State of sea.	Weathe
	Latitude N.	Longitude E.	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.		
	° ′	° ′	Inches	Inches.				
S. S. *St. Regulus.*	15 0	94 10	...	...	E.	6	...	Heavy rai day; squal afternoon.
S. *Marpesia* .	?	?	...	...	S.	6	...	Constant during ing. Wea cleared mid-day wind fell o
S. *Mayo* .	16 20	95 0?	29·89	29·87	N.-E.	2	Smooth	Morning evening sc ly.

The observations indicate that weather was very squally w strong winds and heavy rain in the centre of the Andaman Sea the 2nd.

We have now to trace the progress of the cyclone itself on 2nd.

Observations and account of storm by observer at Port Blair.

The cyclone passed over Port Blair early on the morning of 2nd. The observer, Mr. Carroll, of the Medical Department, who the Meteorological Observer at the Port Blair Observatory, tool valuable series of observations during the storm and also supplied formation from various sources. The following gives the observati he recorded during the cyclone:—

HOUR	BAROMETER.		Wind.	Rain.	Weather remarks.
	Actual.	Reduced to sea-level and constant gravity.			
	Inches.	Inches.			
1st—					
6 P.M. .	29·916	29·773	E.-N.-E	..	Fine weather.
9 P.M. .	·850	·700	...	...	......
2nd—					
1 A.M. .	·602	·451	N.-E.	0·40	Wind rising and com in stormy gusts.
2 A.M. .	·404	·254	N.-E.	0·20	Blowing very hard.
3 A.M. .	28·502	28·359	S.	0·50	Calm between 2 and 3
4 A.M. .	·680	·538	S.	1·05	Blowing very hard.
5 A.M. .	29.240	29·101	S.	0·80	Very squally.
6 A.M. .	·580	·446	S.-S.-E.	0·15	Squally.
8 A.M. .	·852	·712	S.-S.-E.	0·20	
10 A.M. .	866	·726	S.-S.-W.	0·06	

The wind-vane was broken between 3 and 4 A.M. and the anemometer between 4 and 5 A.M.

The following is Mr. Carroll's account of the storm:—

"On the afternoon of the 1st instant, at about 2 o'clock, rain clouds banking up from the east and north-east, soon overspread the sky and burst, attended by strong wind. After a good shower, registering 0·60 inches of rain, the wind abated, leaving the usual gloomy state of weather experienced on a monsoon day. During this shower I noticed that there was some disturbance in the upper currents of air; for, the lower clouds—though moving chiefly from E.-N.-E., were very frequently unsettled, seeming to falter, circle and then move on—the wind-vane at that time was oscillating between N. and E.-N.-E.. However at 4 P.M. the wind having fallen to all ordinary appearance mischief was not expected. About 1 A.M. on the 2nd instant the wind rose in fierce gusts from the north. This was the first indication of coming trouble. The instruments and records of the Tidal Observatory have been destroyed, but the clerk in charge assured me his last barometrical reading at 6 P.M. on the 1st was 29·916." My barometer registered 29·602" at 1 A.M. The mercury continued to fall; at 2 A.M. it registered 29·404"; the wind-vane circling at very great speed, and the wind so strong, apparently from N.-E., that I could not force my way up the ladder to the anemometer. At this time the shingles from the convict barracks and hospitals were being ripped up by the wind. The I. M. S. ***Enterprise***, then in harbour, was either being driven or was forcing her way out at the southern entrance of the Ross harbour, and was whistling apparently in distress (for, as it so happened, it was their death signal). She was driven on the rocks when about half-way out, and was a total wreck, losing all but six hands, before daybreak. Between 2 and 3 A.M. there was a sudden lull, then the wind veered round to southward, and by 3 A.M. the cyclone was at its worst. The barometer reading was 28·502"; and, after a very hard struggle to reach the anemometer a reading was registered as 495+4·9 miles; wind-vane still circling; rain 0·50". Two steam barges, several large lighters, and many boats in the harbour had lost their anchorage, and were at the mercy of the wind and waves. They have all been more or less smashed or otherwise destroyed. Trees of great size were ripped up by the roots. Cocoanut trees were broken off at the crowns like mushrooms; areca-nut trees snapped like matchwood, and the roofs and sides of nearly every building destroyed. At 4 A.M. the barometer rose to 28·680". Another attempt was then made to reach the anemometer. This was accomplished with very great difficulty, and the reading taken at 505+1·4 miles, so that in the hour the wind travelled (505—499·9)+106·4=111·5 miles. The wind-vane had been wrenched off. About 15 minutes after leaving the anemometer the cups were wrenched off too; the platform and hand-rail leading to the instruments were broken off.

Observations on board the barque "*Safir*" at Port Blair.

Mr. Carroll has also forwarded a series of observations taken on board the Norwegian barque "*Safir*," which was anchored during the storm in the shallow harbour opposite Viper Island (about 4 miles to the west of the Port Blair Observatory). These observations, it will be seen, differ very largely from those taken by Mr. Carroll. The following are the observations in question :—

Date.	Hour.	Barometer.		Wind.	Weather remarks.
		Actual.	Corrected and reduced to sea-level and constant gravity.		
		Inches.	Inches.		
1st .	6 P. M.	29·70	30·00		
	7 "	29·35	29·65	E.	Squally with rain and thunder.
	8 "	29·20	29·50	N.E.	Ditto ditto.
	9 "	29·00	29·30	N.E.	……
	10 "	28·80	29·10	…	Hurricane (10 P.M. to 2-30 A.M.).
	11 "	28·70	29·00	N.	……
	12 "	28·65	28·95	N.	Thick, heavy rain.
2nd .	1 A. M.	28·60	28·90	N.	……
	2 "	28·50	28·80	N.	Calm from 2-30 to 2-45 A.M.
	3 "	28·50	28·80	S.W.	Hurricane winds.
	4 "	28·80	29·10	S.S.W.	Squally, with heavy rain.
	5 "	29·20	29·50	S.	Wind began to moderate.
	6 "	29·35	29·65	S.	Squally.
	7 "	29·45	29·75	S.	Ditto.
	8 "	29·50	29·80	S.E.	Ditto.
	9 "	29·55	29·85	S.	Ditto.
	12 "	…	..	S.S.	Fine.

The corrections to the barometer have been determined from the statement made by the captain in the extract from his log that his barometer usually stood between 29·52" and 29·62" at Port Blair. As the barometer during the preceding fortnight that the "*Safir*" had been in Port Blair Harbour ranged between 29·80" and 29·95" (reduced and corrected to sea-level and constant gravity), the correction of the "*Safir*" barometer to reduce her observations at Port Blair to sea-level and constant gravity was hence approximately +·30".

Comparison of barometric observations at the Port Blair Observatory and on board the barque "*Safir*."

These two accounts agree in the facts that the calm storm centre passed over Port Blair, and that its passage was preceded and followed by hurricane winds. The log of the "*Safir*" defines the calm period more exactly than in Mr. Carroll's account. It states it lasted from 2-30 A.M. to 2-45 A.M. Assuming that the rate of motion at the stage was 18½ miles, this would give a breadth in an easterly and westerly direction of between 4 and 5 miles for the calm area.

The barometric observations taken on board the "*Safir*" and at the Port Blair Observatory during the storm differ to such an extent as to demand special investigation to determine which should be accepted as representing the actual changes of pressure due to the passage of the storm. The barometer at the Port Blair Observatory is a Casella's Fortin's (diameter of tube, ·45 inch) which has been in use for some time, and is a thoroughly reliable instrument. Mr.

Carroll is a very experienced and intelligent observer. The barometer on board the "*Safir*" was an aneroid, and experience has shown that the aneroid barometers on board ships are occasionally most unsatisfactory and untrustworthy instruments. The following gives a comparison of the readings taken at the same hours on board the "*Safir*" and at the Port Blair Observatory, in both cases reduced to sea-level and constant gravity—

Date and hour.	Barometric readings at Port Blair Observatory reduced and corrected. (*a*)	Readings on board the "*Safir*" (correction +0·30") (*b*)	Readings on board the "*Safir*" (correction +0·20") (*c*)	Difference of corrected readings (first and second columns.) (*b* - *a*)	Difference of corrected readings (first and third columns.) (*a*—*c*)
	"	"	"	"	"
1st—					
6 P.M.	29·773	30·00	29·50	+0·227	+0·273
2nd—					
1 A.M.	·451	28·90	28·40	−0·551	+1·051
2 "	·254	·80	·30	−0·454	+0·954
3 "	28·359	·80	·30	+0·441	+0·059
4 "	·538	29·10	·60	+0·562	−0·062
5 "	29·101	·50	29·00	+0·399	+0·101
6 "	·446	·65	·15	+0·204	+0·296
7 "	·712	·75	·25	+0·038	+0·462
8 "	·726	·85	·35	+0·074	+0·376

The actual readings of the two barometers during the storm are plotted in plate XVII. It will be seen that they give pressure curves differing very greatly in form, due chiefly to the large differences between the readings at 1 and 2 P.M.

In the case of the "*Safir*" observations, the barometer fell rapidly in the earlier stages of the cyclonic storm (from 6 P.M. to 10 P.M.), and was almost steady during the period of hurricane winds from 11 P.M. to 3 A.M., and it rose much more rapidly as the storm withdrew from Port Blair than it did during its approach. The curve is very unsymmetrical. On the other hand, the Port Blair Observatory curve is fairly symmetrical. It shows a moderate change of pressure in the earlier and later stages of the storm (or moderate gradients in the outer storm area), whilst it gives remarkably steep gradients near the centre in the area of hurricane winds. The curve representing the Port Blair Observatory pressure data is not only in strict accordance with the broad features of the air motion, but resembles in all its important features the pressure curves of stations over which the calm centre of severe cyclones have passed in India, *e.g.*, the False Point cyclone of September 1885 and the Midnapur cyclone of October 1874, given in Plate XXVII of the "Hand-book on Cyclonic Storms in the Bay of Bengal," published by the India Meteorological Department.

In the preceding table the readings of Port Blair Observatory reduced to sea-level and constant gravity. In the third column given the readings on board the "*Safir,*" corrected to sea-level, constant gravity by the use of the correction + 0·30″ determine the manner stated on page 50, and in the fourth column the readi of the same instrument reduced by the use of the correction—0· which gives practically the same pressure in the calm central a when advancing over the "*Safir*" as that which was observed wl passing over the observatory on Ross Island. On either supposit as to the correction necessary for the "*Safir*" aneroid, it will seen that there are great discrepancies between the observati which cannot be explained by difference of position with respec the centre. In the first place, the correction suggested by the c tain's remark that the aneroid usually ranged between 29·52″ a 29·62″ at Port Blair is +·3″, whilst the correction necessary make the two instruments give practically the same pressure w the calm centre was passing over both is —·2″. The differe between these two corrections is ·5″. Again, the differences betw the reduced barometric readings from 3 A.M. to 9 A.M. range on first supposition from ·04″ to ·56″, and on the second supposit from —·06″ to +·46″, showing what may be termed a range of v ation of ·52″. The greatest difference of pressure due to their lative positions when the gradients were steepest was almost certai not more than ·3″.

The only possible explanation of these very large difference that the "*Safir*" aneroid was an untrustworthy instrument, a hence that its readings cannot be accepted as giving the true rec of the pressure changes during the storm. It is hence assumed t the log of the "*Safir*" gives correct data of the time of the p sage of the central calm area, but that the observatory gives corr pressure data of the storm. According to the latter the barometer three-tenths of an inch between 6 P.M. and 1 A.M., a rate of fall wl was rapid enough to show that a cyclonic storm of considerable tensity at least was approaching. Hence, as stated by one of the s vivors of the S.S. *Enterprise,* the captain ordered steam to be got between 10-30 P.M. and 11 P.M., thus evidently anticipating the ea approach of bad weather. Assuming that the calm centre reached observatory about 2-30 A.M., it is almost certain that the barome fell an inch in an interval of half an hour, whilst the storm advance or 10 miles. This gives gradients of extraordinary steepness in fr of the storm. The barometer rose ·56″ between 4 A.M. and 5 A The gradients were very steep in the rear of the storm, but proba considerably less than those which obtained immediately in fro

The captain of the "*Safir*" appears to have also exaggerated the force of the wind at the commencement of the storm. Mr. Carroll states in a letter that at 10 P.M. a fresh breeze was blowing with lightning and rain, but that it was not until midnight that he became alarmed at its force and began to anticipate a severe storm.

Report on the storm in the South Andaman Island by Mr. Portman. (Plate XVI.)

The following extract from a report submitted to the Commissioner of the Andamans by M. V. Portman, Esq., officer in charge of the Andamans, Port Blair, gives a full and interesting account of the destruction effected by the storm in the Andamans :—

"From Port Blair to Kyd Island all the trees were stripped of their leaves and smaller branches, and after passing Barua-tang, 11 miles north of Ross Island, we noticed that many of the larger trees had been blown down.

"At Kyd Island, 18 miles north of Port Blair, the wind had reached its greatest violence and many of the trees were down.

"A mile out at sea the water was black and thick with mangrove mud, and the stench peculiar to mangrove swamps was very powerful. This may be due to the mangrove trees having been torn up by the storm, and the black mud which accumulates round their roots being set free and washed away by the tide.

"At Rogo-lo-chang, 30 miles north of Port Blair, the jungle no longer appeared stripped of its leaves and branches; and at Strait Island, 34 miles north of Port Blair, I learnt that, though heavy rain had fallen, no storm of importance had passed.

"Just south of Strait Island I met five canoes full of Andamanese. They had been at a village near Rogo-lo-chang, 28 miles north of Port Blair, during the storm, and stated that during the night of the 1st they were so frightened by the falling branches that they went into the sea until the storm had passed.

"I proceeded through Colebrooke Passage, 33 miles north of Port Blair, where the jungle was in its usual beauty, not a branch being broken or a leaf blown off, and passed through Humfray Straits to Lekera-lunta and anchored for the night between Bluff Island and the south end of Spike Island. Here, 34 miles north of Port Blair, I found a storm had passed, breaking many of the smaller branches of trees in the jungle, but not of sufficient violence to give the jungle the stripped appearance it has near Port Blair.

"In Humfray Straits a few bamboos were blown about, but all the leaves were not off the trees.

"I learnt, partly from observation and partly from the Andamanese I met near Strait Island, that the cyclone had passed over the Archipelago Islands, stripping the trees south of Tadnia Jurú (a strait 24 miles north of Port Blair), doing considerable damage between that place and Nicholson Island 28 miles north of Port Blair, and apparently leaving Nicholson Island 30 miles from Port Blair untouched. I have sent two parties to look along the coast of the Archipelago Islands for any wrecks which may have occurred.

"On the 9th we steamed down the west coast of the South Andamans. A Breakfast Bay, 28 miles north of Port Blair, the trees again appeared stripped of their branches and leaves, and many trees had fallen.

"At Port Campbell, 20 miles north-west of Port Blair, and in the same latitude as Kyd Island, the wind had evidently been of great violence. Montgomery and Petrie Islands, at the entrance of the harbour, had the majority of their trees down, and the cliff at the south side of the harbour, formerly having a crest of lofty trees, was bare. Portions of the cliff, which is of soft sandstone, had fallen into the sea. From here to Eli-plunta, 5 miles north and 16 miles east of Port Blair, the jungle had the appearance of a forest in England in winter.

"About 5 miles south of Port Campbell I saw some Jarawas on the beach. They have, of course, experienced a great fright, as the jungle in their country is so damaged and have probably received injuries from falling trees. Had I been able to do so, I would have left food and presents for them on the beach, but the heavy sea on the reef prevented my landing.

"At Port Mouatt the damage was not so great as at Port Blair, and further south the wind had been perceptibly less fierce. Termugli Island was not injured, and all the trees on Grub Island were standing with their leaves on, though they were stripped of leaves and branches on the mainland a mile off.

"The jungle in the Labyrinth Island had not suffered much. The trees on the Yaratan hills and at Biriwil-la-Loichera, the south-west corner of the South Andamans, had been stripped of all their leaves and branches.

"I anchored in Portman harbour (Rutland Island) for the night. The jungle on Rutland Island had not suffered much and the leaves were not off the trees.

"On the 10th we proceeded on to the Little Andamans. The jungle on Cinque Passage and Brother Islands showed no sign of a cyclone having passed.

"We anchored in Bunda creek, Little Andamans, at 11 A.M., and were received by a number of "Oonges," both men and women, who had collected on either bank. Some of them swam off on board, and I learnt no storm of special violence had passed, and that Kogio Kai, Tomiti and all the Tambe-ébin people were turtling on the South Brother Island, which they would not be doing had they just experienced a cyclone.

"On the 11th we returned to Port Blair, as the weather looked stormy. On the way up I noticed that the zone of greatest violence of wind commenced at about 11 miles south of Port Blair.

"From the above observations I draw the following conclusions:—The greatest violence of the wind was in latitude 11° 58' north. The zone of violence of wind sufficient to strip the trees of their leaves and branches and to fell several was from latitude 11° 32' N. to latitude 12° 8' N. on the east coast of the islands. The zone only extended to latitude 12° 4' N. on the Archipelago Islands, which are about 15 miles east of Port Blair.

"On the west coast of the islands this zone extended from Lat. 11° 35' N. to Lat. 12° 8' N. The whole storm, including the above and those parts of the islands where the wind had sufficient force to break the branches of the trees, extended on the east coast from Lat. 11° 28' N. to Lat. 12° 14' N., and on the west coast from Lat. 11° 30' N. to Lat. 12° 18' N. Outside of this zone rain and dirty weather undoubtedly occurred, but there was no storm of any exceptional violence.

"Near the southern and northern edges of the zone of great violence the wind seemed to have been capricious, often levelling the trees in one place, and not even blowing the leaves off exposed clumps of trees half a mile away."

Inferences relating to chief features of storm when crossing the South Andaman Island.

The more important inferences from the preceding account are:—

1st.—The storm consisted of an inner area of destructive hurricane winds and of an outer area of comparatively moderate winds.

2nd.—The inner storm area of hurricane winds was not more than (12° 8′—11° 30′=38 geographical miles, or) 45 English miles in width on the east side of the island, and (12° 8′—11° 35′=33 geographical miles, or) 38 English miles on the west side.

3rd.—The diameter of the storm area in which the winds were strong enough to break the branches of trees was (12° 14′—11° 28′=46 geographical, or) 54 English miles.

4th.—The strongest winds, according to Mr. Carroll, lasted from 1 A.M. to 5 A.M., giving a duration of four hours for the passage of the inner storm area across Port Blair, corresponding to a diameter of 75 miles (assuming the velocity of the storm at this stage to have been 18¾ miles).

5th.—The inner storm area was, hence, almost certainly elliptical-shaped, the longest diameter (lying east and west) probably not exceeding 75 or 80 miles, and its shortest diameter (lying north and south) not exceeding 50 miles. A comparison of these data with those of the dimensions of the inner storm area or typhoon when crossing the Malayan Peninsula shows that the storm was practically unchanged in shape or dimensions, and that the direction of the longer diameter of the storm area in both cases approximately coincided with the direction of advance of the storm.

Mr. Portman states that the Andamanese informed him that a similar cyclone occurred many years ago (probably in 1864). He believes, however, for various reasons that it was by no means so severe as the present one, and that the winds were not strong enough to cause the destruction of trees such as occurred on this occasion.

The following account of the destruction caused by the storm at Port Blair was given by Mr. Carroll:—

"From the Chief Commissioner down every man, woman and child in the settlement more or less suffered from wet and exposure, having either partly or wholly unroofed houses as shelter. All the convict barracks and hospitals in the settlement, bazars, and self-supporters' villages, are in most instances complete wrecks, and at present no dry spot is available. The sea-face walls and stone jetties have been destroyed, stones weighing several pounds upheaved and scattered for many yards over roads and adjoining spaces. Roofs of the Co-operative stores, Asiatic Steam Navigation Company's Agent's office, Port Officer's office, Volunteer Drill Hall, the extensive Commissariat godowns and Marine workshop sheds lie scattered over the roads, every tree on Ross Island has been either uprooted or had its branches broken off, and the large trees of the forests deprived of their foliage stand out as so many bare poles. Sea gulls were found dead on the roads, and birds on the wing were dashed against the buildings. The destruction of building has been attended with wounds, injuries and loss of life. At this present moment I do not know the exact numbers, but I am sure I am within bounds in saying that about 40 lives have been lost and thrice that number injured by the falling and collapsing of buildings. All but six of the whole crew of the *Enterprise* (79 in number) have been lost, and several lighter men drowned. The damage done to property will not be rectified for years. The settlement is one scene of desolation."

Storm observations taken on board the ship *Bann* on 2nd November.

The only vessel which was within the storm area during the day was the ship *Bann*. The following gives her meteorological log of the day in full :—

Hour.	Position.		Barometer, Actual.	Wind		Weather.
	Latitude N.	Longitude E.		Direction.	Force.	
			Inches.			
4 A.M.	...	...	29·72	N. E.	2	Light unsteady breeze and threatening appearance. Very threatening to north-east.
8 ,,	...	...	...	N.E.byE.		
10 ,,	...	...	...	...	...	Wind freshening rapidly with high confused sea rolling up from the north.
Noon	12° 11′ by ac	90° 12′ count.	29·42	W.	...	Strong gale from the west, with furious squalls and heavy rain; cyclonic appearance to the north.
1 P. M.	...	...	...	W.S.W.	...	Heavy gale, wind veering to south. Heavy squalls with blinding rain. Appearance of the weather very threatening and cyclonic; very heavy sea running.
4 P.M.	...	...	29·62	S.W.	...	Finer appearance; squalls less violent.
8 P.M.	...	...	29·70	S.	...	Much finer looking to south. Heavy bank of clouds and threatening to the north-west.
Midnight	...	...	29·80	S.	9	Strong gale and hard squalls, with heavy rain.

The preceding extracts show that, although weather looked very threatening to north-east, the *Bann* had light unsteady north-east breezes up to 10 A.M., when she began to feel the influence of the cyclone. At noon she had a strong to heavy gale from the west with furious squalls and heavy rain. The storm centre was at that time in about Lat. 12° 10′ N. and Long. 91° 15′ E., and advancing in a west-north-west direction. The position of the *Bann* (by account) was Lat. 12° 11′ N. and Long. 90° 12′ E., and was almost certainly correct within a few miles. The *Bann* was, hence, less than 80 miles to the west of the centre at that hour. The fact that she had light variable breezes until 10 A.M., when she was not more than 80 miles from the centre, confirms the previous conclusions as to the small magnitude of the storm. The rapid shift of wind in the afternoon, from west to south, is also in strict accordance with the fact that the storm was of small extent, and also indicates that the centre was advancing in a west-north-west direction to the north of the vessel.

November 3rd. (Plate X.)

November 3rd.—The barometric changes of the previous 24 hours were small in amount at all the Indian land stations, and under ordinary circumstances would have been considered of little or no significance.

General meteorological conditions in India.

Pressure had slightly increased in Burma and North-Western India, and fallen elsewhere. The following table gives the more important features of the 8 A.M. pressure data of the 3rd :—

PROVINCE.	Mean change of pressure in previous 24 hours.	Mean variation from normal.	Anomaly.
	"	"	"
Burma	+·013	+·027	—·026
Bengal and Assam	—·017	+·046	—·007
North-Western Provinces and Oudh .	—·006	+·074	+·021
Punjab	+·017	+·104	+·051
Sind and Rajputana	+·018	+·079	+·026
Guzerat and Central India . . .	—·008	+·071	+·018
Central Provinces	—·006	+·071	+·018
Bombay	—·012	+·031	—·022
Madras	—·035	+·013	—·040

Skies were thickly clouded in Burma, and were clouding over in Bengal. The following shows the amount and extent of the change:—

District.	Average amount of cloud at 8 A.M. of		
	1st.	2nd.	3rd.
Burma Coast	5·6	5·4	7·2
Burma Inland	1·0	3·4	6·8
Bengal Coast	0	1·0	8·5
Bengal Inland	0	0·6	8·5
Central Provinces	0	0	0·
North Madras Coast	0·6	1·4	7·4

The rapid extension of cloud over the Bay area and in Bengal and the Peninsula is one of the most characteristic features of storms in the Bay of Bengal.

Summary of the meteorological condition in India on the 3rd.

The following gives a brief summary of the meteorological conditions of the day. Pressure was above the normal, except in Malabar the excess being greatest in the Punjab, where it exceeded a tenth of an inch. Northerly winds prevailed in Bengal and north-easterly to easterly winds in the Peninsula, and calms or variable winds in North-Western India. Winds were hence practically normal in direction. Temperature was above the average, except in the Central Provinces, where it averaged 2° below the normal. Light showers had fallen in South and Central Madras. Skies were clear over the whole of India, except Burma, Bengal and Madras. Sea was smooth to slight at the west coast stations of the Bay, and was rough at Diamond Island. The observations indicated the existence of a depression and cyclonic storm in the centre of the Bay, but gave very feeble indications of the character, extent or intensity of the disturbance.

Weather in the Andaman sea.

The following gives a brief summary of the 8 A.M. observations taken on board vessels in the Andaman Sea and at Port Blair, Nancowry and Diamond Island :—

NAME OF STATION OR VESSEL.	POSITION		BAROMETER.		WIND.		Condition of sea.	Weather.
	Latitude N.	Longitude E.	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.		
	° ′	° ′		Inches				
Nancowry . .	...	...	...	29·931	S.S.E.	Light .	...	Rainfall 1·14 inches; overcast.
Port Blair . .	...	...	...	29·851	S.S.E.	Moderate	...	Rainfall 2·39 inches; overcast.
Diamond Island .	...	...	...	29·917	Calm	0	...	Rainfall 2·22 inches; overcast.
S. *Garnet Hill* .	6 45	95 10	30·00	29·93	S.	...	Smooth	Drizzling rain.
S. S. *Nevasa* .	8 0	98 0	29·96	29·91	E.S.E.	2	...	Cloudy.
S. *Marpesia* .	11 43	94 38	...	...	S.E.	2	...	Clear.
S. S. *Shahjahan* .	14 15	94 50	29·96	29·87	E.S.E.	4	...	Cloudy.
S. S. *Palamcotta* .	15 50	94 15	29·95	29·88	E.S.E.	4	Sea rough.	Hard squalls.
S. S. *Kola* .	Rangoon River.		30.08	29·91	E.	4	...	Fine, clear weather, with passing clouds.

These observations show that weather was reverting to its normal character in the Andaman Sea. The S.S. *Goa*, which left Moulmein for Rangoon at noon, had fine weather with light winds, and the S.S. *Kola*, which left Rangoon for Akyab, had light winds and fine clear weather during the day and night of the 3rd in the north of the Andaman Sea. The S.S. *Shahjahan* between Rangoon and Port Blair had cloudy weather, moderate breezes and slight sea throughout the day. South-east to east winds prevailed over nearly the whole area.

Weather in the Bay of Bengal.

The available information of the weather in the Bay of Bengal on the 3rd obtained from the logs of ships is meagre and unsatisfactory.

The following gives a summary of the 8 A.M. observations utilised i the chart of the day (Plate X) :—

SHIP.	POSITION.				BAROMETER.		WIND.		State of Sea.	Weather.
	Latitude. N.		Longitude. E.		Actual.	Corrected, and reduced to sea-level and constant gravity.	Direction.	Force.		
	°	′	°	′	Inches	Inches				
S. S. *Stella* . .	6	0	89	50	29·98	29·89	W.	4	...	Cloudy. Fin in evening.
S. *London Hill* .	7	50	92	12	...	...	S.S.W.	4	...	Moderate unsteady wind; heavy showers during whole day.
S. S. *Pundua* . .	9	38	83	43	30·02	29·85	S.W. by W.	4	...	Cloudy.
S. S. *Plassey* . .	10	0	83	55	29·88	29·85	N.	2	Heavy north swell.	...
S. *Joseph* . .	10	15	91	50	29·90?	29·85	E.S.E.	6	...	Squally, with heavy rain during day.
S. *Bann* . .	13	30	91	10	...	...	S.S.E.	9	...	Very threatening to N.·E.
S. *Kalakana* . .	13	45	88	15	29·76	...	S.S.W.	...	...	...
S. S. *Congella* . .	14	20	81	40	30·05	29·85	N.E.	...	...	...
S. S. *Baria* . .	14	45	81	40	29·66	29·85	N.N.E.	3	...	...
S. *Lena* . . .	14	50	88	56	...	...	S.	9	Confused .	Moderate to heavy gale during day. Terrific squalls at noon.
S. S. *Japan* . .	15	30	93	10	30·09	29·89	E.	2	High sea from S. W.	Drizzling in morning. Hard squalls in afternoon.
S. S. *Loodiana* .	16	0	85	0	29·90	29·80	N.E.	...	...	...
S. *Mayo* . . .	16	40	94	5	29·90	29·85 ?	N.E.	3	...	Squalls, with rain, overcast in afternoon.
S. S. *Waverley* .	Negapatam				...	...	N.E. by N.	5	Moderate in morning. High in evening.	Overcast.
S. S. *Lincolnshire* .	18	15	86	20	29·78?	29·85	E.	5	Heavy confused sea.	Very heavy rain squalls in afternoon. Fierce rain squalls at midnight.
S. S. *Saint Regulus*	18	15	90	30	...	...	E.	5 to 6	...	Hard squalls and heavy rain until 8 P.M.
S. S. *Meanatchy* .	18	27 (noon)	87	44	30·01	29·88	E.	...	Slight swell from S.-E.	...
S. S. *Arratoon Apcar*	18	35	90	0	29·79	29·85	E.	7	Strong head	Squally with rain.
Barque *Lady Agnes*	19	30 (noon)	88	5	...	...	E.N.E.	9	Confused .	Squally.
S. *Anne Main* .	20	45	90	15	29·86	29·93	N.E.	...	Fresh swell	Overcast. Gloomy, Spitting rain during day.
F. L. V. *Canopus* .	Intermediate station.				30·10	29·96	N.E.	5	Southerly swell.	Wind increased to fierce gale in afternoon

These observations show that weather was not much changed in the south of the Bay. Skies were more clouded and winds slightly stronger. The storm was in the centre of the Bay, and its influence was extending rapidly northwards. Weather was squally, with strong easterly winds over the whole of the north of the Bay in the morning, and the winds intensified rapidly during the day, so that the F. L. V. *Canopus* at the Intermediate Station had a fierce gale in the evening from east (force 9). The S.S. *Meanatchy* and *Arratoon Apcar* and the F. L. V. *Canopus* had a strong southerly swell during the day, due to the storm in the Bay, indicative of its existence and approximate position.

The information when charted shows that the most probable position of the centre at 8 A.M. was latitude 14° 10′ N. and longitude 87° 20′ E. The following gives the position of the vessels nearest to the storm centre at that hour with reference to the centre:—

Vessel.	Position.		Wind		Distance from centre in miles.
	Latitude.	Longitude.	Direction.	Force.	
	° ′	° ′			
S. *Bann*	13 30	91 10	S.S.W.	...	252
S. *Lena*	14 50	88 56	S.	9	108
S. S. *Kalakana*	13 45	88 15	S.S.E.	9	60
S. S. *Arratoon Apcar*	18 35	90 0	E.	7	344

Observations of storm on 3rd November taken on board the S. *Bann*, S. *Lena*, and S. S. *Arratoon Apcar*.

The only vessels in the storm area on this day were the *Bann*, *Lena* and *Arratoon Apcar*.

The ship *Lena* passed through the eastern quadrant of the storm in the day, and continued on her course up the Bay towards the Hooghly, and was again involved in the cyclone on the 6th, near the Sandheads. The following gives her observations of the 2nd and 3rd:—

Ship *Lena*.

Date and Hour.	Position.		Winds.		State of sea.	Weather.
	Lat. N.	Long. E.	Direction.	Force.		
Nov. 2nd.	° ′	° ′				
4 A.M.	...	...	E.	4	Smooth	Overcast.
8 A.M.	...	...	N.-E. Unsteady	Increasing wind.		
Noon	13 19	88 52	N.N.W.	5	...	Squally.
4 P.M.	...	...	N.N.W.	Increasing	...	Heavy rain.
8 P.M.	...	...		8	Moderate, but confused	Raining.
Midnight	...	...	W.	...	...	Overcast.

Ship *Bann*.

The ship *Bann* passed from the western to the eastern quadrant of the storm on the afternoon and night of the 2nd. As the storm advanced westwards she passed into the outer storm area on the morning of the 3rd and advanced in a north-westerly direction up to the head of the Bay, where she again encountered heavy weather on the 6th. The following gives the weather information contained in her log of the 2nd and 3rd :—

Date and hour.	Position.		Barometer.		Wind		State of Sea.	Weather.
	Latitude N.	Longitude E.	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.		
	°	"	Inches.	Inches.				
3rd. 4 A.M. .	...	...	29·75	?	S.	9	Very high and confused.	Hard squalls, with heavy rain.
8 A.M. .	...	...	·80	?	S.S.E.	...	...	5 A. M.—Fine appearance. Barometer working steadily.
Noon .	13 41	91 23	·80	?	S.E.	9	High	Squally. P. M.—Fresh gale, with heavy clouds and rain.
4 P.M. .	...	...	·78	?	S.E. (Gale moderating.)	...		......
8 P.M. .	...	...	...	...	S.E.	7	...	Dark and gloomy-looking to the westward.
Midnight.	...	...	...	...	S.E.	6	...	Dark and overcast with rain.

The S. *Bann* was from 250 to 300 miles to the east of the centre on the afternoon and evening of the 3rd. She had a strong to a fresh gale during the whole of the afternoon. The weather improved during the night. She had strong south-east winds, with occasional squalls and rain during the next 36 hours.

The ship *Kalakana* was probably nearest to the centre on the morning of the 3rd. The information in her log is very meagre.

Log of ship *Kalahana.*

The following gives extracts from her log for the 2nd and 3rd:—

DATE AND HOUR.	POSITION.		BAROMETER.		WIND.
	Latitude N.	Longitude E.	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.
2nd.	° ′	° ′	"	"	
4 A.M. .	...	...	30·00	29·87	N.-N.-E.
8 A.M. .	...	...	·01	·87	N.-N.-E.
Noon .	13 15	88 33	·00	·87	E.
4 P.M. .	...	...	29·96	·83	N.-E.
8 P.M. .	...	...	·92	·79	N.-N.-W.
Mid-night .	...	...	·66	·53	N.-N.-W.
3rd.					
4 A.M. .	...	...	·72	·59	W.-N.-W.
8 A.M. .	...	...	·80	·67	S.-S.-W.
Noon .	13 47	88 19	·88	·75	S.
4 P.M. .	...	...	·88	·75	S.-S.-W.
8 P.M. .	...	...	·89	·76	E.-S.-E.
Mid-night .	...	...	·91	·78	E.-S.-E.

No information of the weather or strength of her winds is available. The observations of the barometer and wind show that she was nearest to the centre between midnight and 4 A.M., and that at the latter hour the centre was probably 40 or 50 miles to the north. Her position by account at that time was Lat. 13° 40′ N. and Long. 88° 20′ E. It is however almost certain that she was considerably further to the west, and it is hence not possible to use her information to fix the position of the centre at midnight of the 3rd.

Inferences respecting storm from data of 3rd November.

The whole of the observations indicate that the storm area was extending and that the extension was occurring most rapidly in the eastern and southern quadrants of the storm area. This is most clearly shown by the weather experienced by the S.S. *Lincolnshire*, *Regulus*, and *Arratoon Apcar*. The S.S. *Saint Regulus*, 350 miles north-east of the storm centre at noon, had hard squalls, with heavy rain; the S.S. *Lincolnshire*, 300 miles north-north-west of the centre at noon, had a stormy gale, with violent rain squalls; and the *Arratoon Apcar*, 350 miles north-east of the centre at noon, had very squally weather, with strong north-east winds. It is hence evident that the area of the strong winds and gales, and of severe squalls, had extended to a distance of at least 350 miles to the north-east and south-east of the centre. In the absence of information it is not possible to state whether the extension of the area of squally weather and gales occurred to the same extent in the western quadrant, but the data of the *Plassey*, *Waverley*, and other vessels off the Coromandel coast appear to be opposed to it.

November 4th. (Plate XI.)

November 4th.—Pressure decreased over the whole of India. The fall was greatest in the Madras, Orissa and West Bengal coast districts, where it ranged from a tenth to a sixth of an inch. Skies were overcast in the North Madras coast districts, and were more clouded than hitherto in Bengal. Rain had, however, not yet commenced to fall in the coast districts of North Madras or in Orissa or Bengal : —

The following, giving mean cloud data at 8 A.M. for the 2nd, 3rd and 4th, shows the extension of cloud to the north and north-west of the area of depression:—

PROVINCE.	MEAN CLOUD AMOUNT AT 8 A.M. OF		
	2nd.	3rd.	4th.
Burma	4·7	7·3	5·4
Bengal and Assam . . .	1·1	5·6	7·9
North-Western Provinces . .	0	0	1·3
Punjab	0·4	0·1	1·
Bombay	2·7	3·3	1·9
Central Provinces . . .	0	0·6	2·4
Guzerat and Central India . .	0	0	0·6
Sind and Rajputana . . .	0	0·3	0
Madras	6·9	7·2	5·3

Weather conditions in India.

The following gives a summary of the 8 A.M. observations at the stations nearest to the storm at that hour :—

STATION.	PRESSURE.			WIND.		Humidity. at 8 A.M.	Cloud at 8 A.M.	Rainfall of previous 24 hours.	Weather and sea.
	8 A.M. reduced to sea level and constant gravity.	Change in past 24 hours.	Variation from mean of day.	Direction at 8 A.M.	Miles per hour past 24 hours.				
	"	"	"					"	
Cocanada .	29·753	—·118	—·120?	N.-W.	5	59	10	0	Sea very rough.
Vizagapatam .	·727	—·142	—·162	N.-W.	6	52	10	0	Sea rough.
Gopalpur .	·739	—·151	—·155	N.-N.-E.	21	90	10	0·08	Sea very rough.
False Point .	·790	—·112	—·122	N.-N.-E.	16	84	10	0·20	...
Saugor Island	·869	—·074	—·049	E.-N.-E.	9	91	10	0·02	Sea slight.

These observations indicate that there was a largish disturbance off the coast of the Circars and Ganjam, and that the centre was probably nearest to Vizagapatam, but they give no definite information of the intensity of the storm. The most noteworthy features of the observations were the very dry north-west winds at Cocanada and Vizagapatam, and the absence of rainfall in the outer area of the disturbance. The following give the 4 P.M. observations at four stations on the north-west coast of the Bay:—

STATION.	PRESSURE.			WIND.		HUMIDITY.		CLOUD. 4 P. M.	Rain-fall, 8 A.M to 4 P.M.	Wea-ther.
	Actual, 4 P.M. reduced ro sea-level and constant gravity.	C hange in past 24 hours	Varia-tion from mean of day.	Direction at 4 P.M.	Miles per hour. 10 A.M. to 4 P.M.	Mean of 10 A.M and 4 P.M.	4 P.M.			
	"	"	"							
Vizagapatam	29·673	—·107	—·202	N.-W.	6	50	49	10	...	Over-cast.
False Point	·732	—·147	—·153	N.-N.-E.	24	93	93	10	0·93	Squally.
Shortt's Island.	·858	—·047	?	N.-E. & E.	17	?	91	10	0·40	Squally.
Saugor Island.*	·822	—·076	—·059	N.-E.	16	87	91	10	...	Threat-ening.

* Reduced to 32° F. only.

These observations show that winds were unchanged in direction at these coast stations, but that their force was increasing rapidly at False Point and Saugor Island, due chiefly to the extension of the storm area during the day.

The following gives an account of the weather at Vizagapatam during the whole period from the 3rd to 7th furnished by the Port Officer:—

DATE.	Weather.
3rd.	Dull sky, with north-east winds. Sea rough and boisterous.
4th.	Bright sky, with light north-west winds. Sea rough, with unsettled weather.
5th.	Clear sky, with south-west winds. Sea smooth.
6th.	Clear sky, with light south-east winds. Sea pefectly calm.
7th.	Weather fine and clear, with light north winds. Sea smooth.

It shows that the storm did not affect the weather at Vizagapatam on the 4th to any important extent. Weather was unsettled and sea rough, but the north-west winds gave clear skies during the greater part of the day.

Meteorology of the Bay of Bengal.

The meteorological data of this date furnished by the ships in the Bay are very unsatisfactory, as they do not enable the position

of the centre to be determined exactly at any period during the
The following table gives a summary of the 8 A.M. data :—

SHIP.	POSITION.		BAROMETER.		WIND.		State of sea.	Weat
	Latitude N.	Longitude E.	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.		
			"	"				
S. *Eurydice* .	9°5′	92°30′	...	...	S.-E.	...	......	Hard sq much ra
S. *London Hill*	9°45′	91°57′	30·15	29·87	S.-E.	...	......	Squally.
S. S. *Pundua* .	...	...	...	...	...	...	......	......
S. S. *Loodiana*.	12°30′	83°50′	29·90	29·80	W.N.W.	...	Moderate sea	Fine and
S. *Joseph* .	13°0′	91°45′	...	...	S.-E.	5	......	Squalls, rain.
S. S. *City of Vienna*.	13°25′	84°40′	29·84	29·75	N.-W.	3	Rough sea (N.-E.)	......
S. S. *Plassey* .	13°30′	84°50′	29·48	29·75	N.-W.	5	......	Squally heavy ra
S. S. *Shahzada*	15°34′	94°27′	30·00	29·87	S.-S.-E.	1	......	Showery.
S. *Kalakana* .	15°35′	89°31′	29·76	29·73 ?	E.-S.-E.	...	......	......
S. S. *Congella* .	16° 5′	83° 20′	29·92	29·72	N.-W.	...	Heavy confused sea.	......
S. S. *Baria* .	16° 45′	83° 45′	29·50	29·69	N.by W.	4	......	......
S. S. *Lawada* .	15° 58′	96° 0′	30·10	29·90	S.-W.	2	......	Fine.
S. S. *Kasara* .	Off Kyouk	Phyoo	30·04	29·88	E.	3	......	Swell westwar squally night.
S. S. *Waverley*.	18°0′N	85°30′?	29·60	...	N.	9	High confused sea.	Heavy sq
S. S. *Meanatchy*	18° 18′	88° 20′	29·84	29·71	S.-E.	7	High heavy S.-E. swell.	Weather derating
S. S. *Mayo* .	At Akyab		29.93	...	N.-N.-E	...	......	Overc drizzling
S. S. *Japan* .	18° 30′	90° 55′	30·06	29·86	S.-S.-E.	...	......	Hard sc and rain.
S. S. *Nubia* .	18° 54′	87° 15′	29·74	29·7	E. by N.	6-7	......	Heavy s and rai
Barque *Lady Agnes* . .	19° 45′	86° 30′	...	...	E.-N.-E.	10	High long sea.	Hard squ
S. S. *Regulus* .	Anchored at E. Channel		?	?	E.	4	......	......
F. L. V. *Canopus* . .	...	...	30·03	29.91	E.	5	......	Light squ
F. L. V. *Star* .	...	...	30·03	29·89	E.-N.-E	5	......	......
S. S. *Lincolnshire* . .	2° 10′	88° 10′	29·80	...	E.-N.-E.	5	......	Heavy squalls.
S. S. *Canara* .	Diamond Harbour		29·90	...	N.-E.	2	......	Overcast.

Weather in the Bay.

The preceding data show that weather was very squally
strong southerly winds in the eastern half of the entrance to
Bay. It was fine and clear with light to moderate winds off
East Ceylon and Coromandel coasts and also over the greater
of the Andaman Sea. Weather was more or less disturbed over
centre of the Bay, and squally weather had now extended to

ead of the Bay. The light vessels reported squalls and fresh E.-.N-E. winds in the morning. Weather was gloomy and skies overcast with north-east winds in South Bengal.

Discussion of observations of vessels involved in the storm on 4th November.

The only vessels which were within the storm area during the day were the S.S. *Waverley*, *Baria*, *Nubia* and *Meanatchy* and the Barque *Lady Agnes*. The S.S. *Japan* also experienced severe weather.

S. S. *Baria*.

The S. S. *Baria* passed through the storm on the night of the 4th. The following gives her observations from noon of the 4th to the same hour of the 5th:—

DATE AND HOUR.	POSITION.		BAROMETER.		WIND.		State of sea.	Weather.
	Latitude N.	Longitude E.	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.		
			"	"				
4th. Noon	17° 9'	84° 3'	29·44	29·74	N. by W.	4		
4 P.M. .	...	...	·35	·65	N. by W.	8		
8 P.M. .	...	...	·35	·65	W. by N.	9	No information.	No information.
Midnight	...	...	·34	·64	S.-W. by W.	9		
5th. 4 A.M. .	...	...	·26	·66	S.-W.	11		
8 A.M. .	...	...	·46	·76	S.-W. by W.	5		
Noon .	18° 28'	85° 27'	·44	·74	S.-W. by W.	...		

The *Baria*, judging from her barometric observations, was nearest the storm centre shortly after 8 P.M., when she had W. by N. winds, force 9. The winds increased for some time afterwards, and she had the strongest winds, from south-west, at 4 A.M. of the 5th, when their force was 11. The winds quickly moderated and at 8 A.M. she had fresh south-west winds, force 5.

S. S. *Meanatchy*.

The S. S. *Meanatchy* was crossing the Bay at this time between Gopalpur and Rangoon. She left Gopalpur on the evening of the 2nd. The Captain judged by the increasing winds, falling barometer, and slight swell, that there was a cyclone to the south-east of the vessel, and he modified his course during the next 48 hours to avoid passing into the storm area. The following gives a summary of h observations on the 4th :—

DATE AND HOUR.	PENTIONS.		BAROMETER.		WIND.		State of Sea.	Weather.
	Latitude N.	Longitude E.	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.		
			"	"				
4th.								
1 A.M. .	...	...	29·87	29·74	N.-E.	9	High confused sea.	Hard squal 3 A.M. to 3-20 A dead calm, wi heavy rain.
4 A.M. .	...	...	·79	·66	E.-S.-E.	8	Considerable sea.	Squally with heavy rain.
6 A.M. .	...	...	·79	·66	S.-E. by E.	...	...	......
8 A.M. .	...	...	·84	·71	S.-E.	8	Swell from S.-S.-W.	Weather mode ating.
Noon .	18° 18′	88° 20′	·86	·73	S.-E.	7	......	Wind and s moderating.
4 P.M. .	...	...	·83	·70	S.-S.-E.	7	Decreasing.	Squalls less s vere. Heavy rai
8 P.M. .	...	...	·95	·82	S. by E.	6—7	......	Weather cleari to E.
Midnight	...	...	·95	·82	S.-E. by E.	6—7	Moderate.	Fine with passi clouds.

The *Meanatchy* was hence quite in the outer storm area durii the day and experienced a moderate to strong gale until the evenin when, by running to the east, she passed into fine cloudy weath with moderate sea and strong breezes.

S. S. *Nubia.*

The S.S. *Nubia,* which was proceeding from Calcutta to Lond passed throgh the eastern quadrant of the storm on the 4th. T following gives the meteorological data relating to the weather of t 4th in her log:—

DATE AND HOUR.	POSITION.		BAROMETER.		WIND.		State of Sea.	Weather.
	Latitude N.	Longitude E.	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.		
			"	"				
4th.								
2 A.M..	...	...	29·83	29·81	E.-N.-E.	6	High S.-E. swell.	Showery.
4 A.M..	...	...	·78	·76	...	...	... ...	Showery.
6 A.M..	...	...	...	...	...	...	Very high confused sea.	Torrents of r at times.
8 A.M..	...	...	·74	·72	E. by N.	-7	......	Heavy squalls rain.

Date and Hour.	Position.		Barometer.		Wind,		State of Sea,	Weather,
	Latitude N,	Longitude E,	Actual.	Corrected reduced to sea level and constant gravity,	Direction.	Force,		
			"	"				
Noon .	18° 51′	87° 15′	29·70	29·68	E.	8	Confused E.-N.-E. swell.	Heavy squalls.
2 P.M..	...	...	·64	·62	E.-N.-E. to E.		......	......
3 P.M..	...	...	·63	·61	...		... ..	......
4 P M..	...	...	...	...	S.-E to E.	—	......	Rain squalls.
6 P.M..	...	...	·68	·66	E.	...	......	Torrents of rain from 7 to 8 P. M.
10 P.M. .	...	...	·27	·70	E. to E.-S.-E.	6	Less	......
Midnight.	...	...	·71	·69	S.-E.	...	......	Heavy rain squalls at times.

The *Nubia* was quite on the outskirts of the eastern quadrant of the storm. She steered for some hours to the east in the middle of the day. She was probably in the same latitude as the storm centre about midnight, but was too far distant from the centre to give its position at that time.

November 5th. (Plate XII.)

5th November.—Pressure had continued to give way over the whole of the Indian area, but the changes were small except in North-Madras, the Central Provinces and North-Eastern India, where the fall was due to the advancing cyclone.

Weather in India.

Skies were now overcast in Orissa, Chota Nagpur, South Bengal and Assam, and were partially clouded in the Gangetic plain as far west as Allahabad. Rain was falling in South Bengal, Orissa and Chota Nagpur, but was light, except in Orissa immediately in front of the cyclonic storm, where the rainfall was excessive.

8 A.M. observations at stations on North-West coast of the Bay.

The following gives 8 A.M. observations at stations on the Ganjam and Orissa coasts nearest at this time to the storm centre :—

Stations.	Pressure (8 A.M.).			Wind.		Cloud proportion, 8 A.M.	Rainfall in past 24 hours.
	Actual, reduced to sea-level and contant gravity.	Change in previous 24 hours.	Variation from normal.	Direction, 8 A.M.	Average velocity in miles per hour.		
	"	"	"				"
Vizagapatam .	29·703	—·024	—·191	W. . .	3	10	*Nil.*
Gopalpur .	·587	—·152	—·311	W.-N.-W.	29	8	2·84
False Point .	·571	—·217	—·346	E. . .	25	10	3·84
Cuttack . .	·571	—·247	—·345	N.-E. .	12	10	2·48
Shortt's Island*.	·711	—·167	...	E.-N.-E. .	15	10	1·20
Saugor Island .	·777	—·092	—·147	E.-N.-E. .	15	10	0·09

* Reduced to 32° F. only.

These observations indicate that the cyclone on the morning of t 5th covered Ganjam and Orissa and the adjacent portion of the B area. The barometric readings and wind data at these statio showed that the storm was one of very considerable extent a intensity. The centre at 8 A.M. was, as is established in the succe ing discussion, about 10 miles east of Puri, and hence off t South Orissa coast. It was advancing in a north-easterly directi towards False Point.

Weather in Bengal.

The following table gives 8 A.M. observations taken on boa ships in the Bay of Bengal on this day :—

SHIP.	POSITION.		BAROMETER.		WIND.		State of sea.	WEATHE
	Latitude N.	Longitude E.	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.		
	° ′	′	″	″				
S. S. *Ursa* . .	9 25	83 15	..	...	N-E.	4	...	Hard swell fr N.-E.
S. S. *Clan Matheson.*	10 5	81 20	29·85	29·84	N.-W.	4	N.-E. swell	Fine.
S. *Eurydice*. .	11 0	91 20	...	...	S.	...	...	Squally.
S. S. *Wildcraft*	11 55	84 55	...	...	S.-W.	2	Heavy N.-E. swell.	Fine.
S. *Loudon Hill*.	13 5	92 15	...	...	S.-E.	2	...	Cloudy.
S. *Joseph* .	14 25	91 50	...	...	?	4	...	Squally, hea rain.
S. S. *Lawada* .	16 20	92 30	30·04	29·84	E.	4	E. swell .	Fine.
S. S. *Plassey* .	16 4	86 50	29·48	29·75	S.-W.	4	Heavy cross sea.	Fine
S. S. *Meanatchy*	17 12	91 30	29·97	29·84	S.-E. by E.	5 to 6	Moderate .	Overcast.
S S. *City of Vienna.*	17 30	86 30	29·66	29·66	S.-S.-W.	3	Rough cross sea.	Clear. W increased violent g at 9 P.M.
S. *Kalakana* .	17 57	...	...	...	...	...	...	......
S. S. *Waverley*.	18 0	86 0	...	...	S.-W.	7	...	Strong g and viol squalls gra ally incre ing in fo during day
S. *Eurydice*. .	18 10	86 0	29·82	29·65	W.-S.-W.	5	...	......
S. S. *Baria* . .	18 12	85 10	29·46	29·65	S.-W. by W.	5	...	......
S. S. *Shahsada*.	18 15	91 2	30·02	29·80	S.-S.-W.	5	...	Squally.
S. S. *Nubia* .	18 44	87 5	29·76	...	S. by E.	6	Tumultuous	......
S. *Lady Agnes* .	(?)	?	...	...	...	...	...	......
S. S.*Lincolnshire*	21 0	88 10	29·78	29·69	E. by S.	6	...	......
S.S.*Japan* . .	21 40	88 20	30·00	29·80?	E.	5	...	......
S. S. *Canara* .	Anchored near Saugor Island.		29·77	29·77	E.-N.-E.	6	...	Light rain.
S. S. *Kola* . .	Near Sandoway (10 miles N.)		30·04	29·88	N.	2	...	Fine.
S. S. *Goalpara*.	14 41	80 56	29·96	...	N.	4	Big swell .	Cloudy.
F. L. V. *Canopus*	21 14	88 11	29·82	29·76	E.-S.-E.	7	S. swell .	......
F. L. V. *Star* .	21 26	88 6	29·81	29·75	E.-S.-E.	5	Rough .	......
S. S. *Regulus* .	Near E. Channel Light ship (30 miles S.).		...	...	E.-S.-E.	9	High cross sea.	Heavy r cyclone midnight.

These observations show that conditions were unchanged in the south of the Bay, where light to moderate winds obtained and weather was generally fine and cloudy. Occasional squalls were experienced, *e.g.*, the S. *Eurydice*, in Lat. 11° N. and Long. 91°20′ E., had squally weather during the day and the S. *Joseph*, in Lat. 14°25′ N. and Long. 91° 50′ E., had squalls, with heavy rain, in the morning. In the centre and north of the Bay cyclonic winds of indraught prevailed, and were of force 8 and upwards between the 18th and 21st parallels of latitude and to the west of the 90th meridian. The storm area was hence much larger than on the 2nd and 3rd, and had increased considerably in extent during the previous 24 hours, and at the same time the storm had not diminished in intensity.

Ships and ports within inner storm area during day,

The ship *Lady Agnes* encountered the full strength of the storm on the night of the 4th and morning of the 5th. The storm centre passed a little to the east of Gopalpur and Puri during the morning and over False Point in the afternoon. It advanced a few miles to the east of Shortt's Island at the mouth of the Dhamrah river late in the evening. The following gives the accounts of the storm as experienced by the *Lady Agnes* and at these stations.

The ship *Lady Agnes*, bound, as stated in her log for Balasore from Colombo, encountered the storm on the 4th and 5th. The following gives extracts from her log. No (mercurial) barometer readings, it may be noted, are given in consequence of the instrument having been broken during the gale:—

DATE AND HOUR.	POSITION.		WIND.		Weather.
	Lat. N.	Long. E.	Direction.	Force.	
Nov. 2nd.					
A.M. . .	...	...	N.-E. .	...	Increasing breeze, with fine clear weather.
Noon . .	18° 57′	87° 30′	E. . .	...	Strong breeze and cloudy.
Afternoon .	...	...	...	...	Wind veered to S.-E. in a squall, but veered to E. again.
Midnight . .	...	...	E. . .	6—7	
Nov. 3rd.					
A.M. . .	...	...	E.-N.-E. .	8	Brisk gale.
4 A.M. . .	...	...	...	...	Squally with passing showers.
Noon . .	19° 30′	88° 5′	...	8—9	Increasing gale and squally, with a confused sea. Overcast.
8 P.M. . .	...	...	...	...	False Point Light N. W. by N., distant 19 miles.
Midnight .	...	...	E.-N.-E. .	9	Strong gale. High cross sea.
Nov. 4th.	...	...	E.-N.-E. .	...	Increasing gale and hard squalls. High cross sea.

DATE AND HOUR.	POSITION.		WIND.		Weather.
	Lat. N.	Long. E.	Direction.	Force.	
6 A.M.	...	...	...	9—10	Hard gale; hazy weather, but no rain.
Noon	19° 45′ (Acco	86° 30′ unt).	E.-N.-E.	...	Hard gale with hard squalls and a very high cross sea.
4 P.M.	...	...	E.-N.-E.	...	Squalls heavier.
9 P.M.	...	...	...	11	Terrific squalls.
Midnight	...	...	E.-N.-E.	11	Terrific gale, with a high confused sea.
Nov. 5th. A.M.	...	...	E.-N.-E.	11	Cyclone increasing with terrific squalls.
1 A.M.	...	...	...	...	Cut away the foremast to ease the vessel. It took the main top mast and jibboom along with it. Shortly after the main mast went, taking mizen mast head, top mast and gaff along with it, smashing the boats rails and bulwarks, breaking two beams, bursting in the decks, etc., in fact leaving the ship a complete wreck.
3 A.M.	...	...	N.	12	Hurricane winds with tremendous sea.
4 A.M.	...	...	N.-W.	12	Wind continued with unabated fury. Sea tremendous.
7 A.M.	...	...	S.-W.	...	Wind decreasing and sea going down.
8 A.M.	...	...	S.-W.	...	

The *Lady Agnes* began to experience strong cyclonic winds on the morning of the 3rd, when she was at least 350 miles to the north of the centre. She drifted westwards during the day near the South Orissa coast. On the morning of the 4th, when she was about 200 miles to the north of the centre, she experienced a hard gale with hard squalls. The centre on the 4th recurved through north-north-west to north-north-east and rapidly approached the ship *Agnes*. In the evening the wind had increased to a terrific gale from east-north-east. At 1 A.M. of the 5th, when the vessel was probably off the Ganjam coast, east of Gopalpur, it was necessary to cut away the foremast. She was nearest the centre between 3 A.M. and 4 A.M., at which time she had hurricane winds with a tremendous sea. She was then probably not more than 15 or 20 miles from the centre. She was carried rapidly under the force of the winds and storm currents from the west to the south-east quadrant of the cyclone, and was gradually left behind on the morning of the 5th. Hence weather rapidly improved, and she had moderate winds and fine weather on the afternoon and evening of the 5th.

The ship *Lady Agnes* was nearest to the storm centre between 3 and 4 A.M. of the 5th, when she was in about Lat. 19° 10′ N. and Long. 85° 20′ E., and hence the storm centre, which was about 15 miles to the east was in Lat. 19° 10′ N. and Long. 85° 35′ E. at that hour.

The following statement of the remarkable performance of the aneroid barometer on board the ship *Lady Agnes* deserves record:—

> "Our aneroid barometer did not register right, as it only fell from 30·00 to 29·80 before the full force of the cyclone burst upon us, and during the six hours during which it raged at its utmost violence and with hurricane force our aneroid did not fall any more, but rose gradually to 30 inches, as the fine weather set in."

Observations at Gopalpur during the storm.

The following gives the observations taken at Gopalpur during the afternoon and night of the 4th and morning of the 5th:—

Hour.	Pressure.	Wind.		Rainfall since previous observation.	State of sea.	Weather.
	Actual reduced to sea level and Lat. 45°.	Direction.	Average velocity in miles per hour.	″		
4th. 11 A.M.	29·695	N.	22	0·15	...	Squally.
2 P.M.	·570	N.	28	0·55	...	Drizzling.
5 P.M.	·539	N.-N.-W.	27	c·36	Tremendous.	Stormy, with heavy squalls.
8 P.M.	·537	N.	25	0·36	...	Squalls more violent.
11 P.M.	·474	N.	42	0·56	...	Gale.
5th. 2 A.M.	·391	N.-N.. W.	37	0·28	...	Hard gale and squally.
5 A.M.	·469	W.-N.-W.	32	0·46	...	......
8 A.M.	·587	W.-N.-W.	25	2·84	Sea high.	......

The observer reported that the calm centre passed over the station between 2 A.M. and 5 A.M., but this was evidently a mistake. The observations furnish no proof of the statement, and it is opposed to the data of the ship *Lady Agnes* and other vessels.

The Gopalpur observations indicate that the centre was to the east of that station between 2 A.M. and 5 A.M., of the 5th and probably about 3 A.M. or 4 A.M., at a distance of not more than 40 or 50 miles, and hence that its position at 4 A.M. of the 5th was most probably in Lat. 19° 15′ N. and Long. 85° 30′ to 85° 40′ E.

Observations of the storm at Puri.

The next coast station in point of order which furnishes data towards determining the position of the centre is Puri:—

HOUR AND DATE.	PRESSURE.	WIND.		Rainfall.	Weather.
	Actual reduced to sea-level and constant gravity.	Direction.	Velocity per hour in miles.		
	"			"	
8 A.M., 4th	29·732	N.-E.	16	0·15	
4 P.M.,,	·612	N.-E.	48		
6 P M., ,,	·598	N.-E.	30		
8 P.M., ,,	·598	N.-E.	18		
10 P.M., ,,	·586	N.-E.	17	...	Blowing heavy.
2 A.M., 5th	·360	N.-E.	...	...	Violent wind.
4 A M., ,,	·292	N.-E.	...		
4-20 A.M., ,,	·266	N.-E.			
5 A.M.	·160	N.-E.			
6 A.M.	·068	N.-E.			

The observer took observations at 5 minutes' intervals from 2 A.M. to 4-20 A.M., and ceased to record observations at 6 A.M. during the most interesting period of the storm, apparently in consequence of the violence of the winds.

His account of the storm is that it began at 10-30 P.M. of the 4th, and lasted until 1-30 P.M. of the 5th. During this period 13 inches of rain fell. The observer also states that the wind blew at the rate of 96 miles an hour at 9 P.M. of the 4th. This, however, is very doubtful. He also adds that it blew most heavily between 7 and 10 A M. of the 5th, when it was utterly impossible to take readings of the anemometer on account of the violence of the wind. The anemometer was blown away shortly after 10 A.M. The wind was from north-east during the greater part of the storm and shifted rapidly to west-north-west between 7 A.M. and 10 A M. Much damage was done to houses and many lives are reported to have been lost in the Chilka lake by the upsetting of boats.

This information is, it is to be regretted, very incomplete. It, however, suggests that the cyclonic centre passed near to Puri. The readings of the barometer, compared with those taken at False Point indicate that the lowest pressure probably occurred at Puri from two to two and a half hours after the last observation (taken at 6 A.M.), and hence that the centre was nearest to Puri between 8 A.M. and 8-30 A.M. Puri was at that time certainly not more than a few miles from the calm centre, but appears to have been outside the calm area, as there is no mention in the report of a period of calm having occurred during the storm. Assuming that the centre was not more than 10 miles to the east of Puri when nearest, this would give the position of the centre as Lat. 19° 48′ N. and Long. 86° 5′ E. at about 8-30 A.M.

Observations of storm at False Point.

The storm centre passed over False Point in the afternoon between 4-5 and 4-45 P.M. Two series of observations are available, one taken by the observer at the Light-House and the other from the Port Officer. In the former the pressure is obtained from the readings of a Casella's Fortin barometer, the tube of which is ·45 inch in diameter and in the latter from an aneroid barometer. The two positions are about 6½ miles distant in a direct line. The observations show slight discrepancies, such as might be expected in comparing observations taken with a mercurial and an aneroid barometer.

The Port Officer, Mr. Workman, was formerly Light-House keeper and acted as observer for many years, and hence so far as accuracy of observation is concerned, the two series are equal in point of value.

Comparison of observations at the Light-House and Port Office.

The following gives a complete statement of the two sets of barometric readings corrected :—

DATE AND HOUR.	PRESSURE AT		WIND AT		WEATHER EXPERIENCED AT	
	Light-House.	Port Office.	Light-House.	Port Office.	Light-House.	Port Office.
5th November.	"	"				
8·30 hours.	29·596	29·600	E	N.-E.	Blowing a gale with heavy rain.	Squalls with blinding sheets of rain.
9	·594	·600	E.	N.-E.		9-15, a most terrific squall from E. with blinding sheets of rain.
9-30	·586	·590	E.-S.-E.	E.	9-30 to 10-30, wind increased to a hard gale.	......
10	·560	·570	E.-S.-E.	E.		
10-30	·526	·540	S-.E.	E.-S.-E.	Severe gale with blinding rain.	Wind increased to hurricane with very severe squalls.
11	·512	·540	E.-S.-E.	E.-S.-E.	Terrific squalls with heavy rain.	Ditto.
11-30	·436	·530	E.-S.-E.	E.-S.-E.	Hard gale with blinding rain.	Ditto.
12-30	·316	·420	E.-S.-E.	E.-S.-E.	Clouds travelling at an enormous rate.	Ditto.
13	·250	·350	E.-S.-E.	E.-S.-E.		
13-30	·156	·300	...	E.-S.-E.	......	13-45, blowing a violent hurricane, with most terrific squalls and blinding sheets of rain.
14	·030	·210	S.-E.	E.-S.-E.	13 to 14-30, wind blowing with hurricane force and blinding rain.	Ditto.
14-30	28·658	·090	S.-E.	E.-S.-E.	......	Ditto.
15	·356	28·890	S.-E.	E.-S.-E.	14-30 to 15-30, wind most terrific with blinding rain.	Ditto.

Date and Hour.	Pressure at		Wind at		Weather experienced a	
	Light-House.	Port Office.	Light-House.	Port Office.	Light-House.	Port Offic
5th November.	"	"				
15-30	28·180	28·690	S.-E.	E.-S.-E.	……	Blowing a violent hurri with most te squalls and b ing sheets of
15-45	·012	·590	E.-S.-E.	E.-S.-E.	Clouds not so dense. The barometer remained steady for a short time and ceased pulsating.	……
16	·084	·410	E.-S.-E.	E.-S.-E.	Blowing a moderate gale; rain decreasing; break in clouds.	16-12, wind denly lulled, blew in h gusts.
16-15	·122	·260	S.-E.	E.-S.-E.	16-5 to 16-45, wind ceased, a dead calm followed by light variable winds, lasted until 16-45.	16-15 to moderate br with heavy cast sky and rainy weathe
16-30	·166	·240	N.-W.	N.-E.	……	……
17	·180	·190	N.-W.	N.	Blowing a hurricane with blinding rain.	Strong breeze heavy gusts heavy overcast
17-30	·486	·300	N.-W.	N.	Force of wind at this time was most terrific.	Wind increase hard gale heavy squalls blinding shee rain. 17-40, blowin violent hurric with most te squalls and b ing sheets of
18	·796	·570	N.-W.	N.-W.	……	17-50 to hurricane ing with red ed force most te squalls and b ing sheets rain.
19	29·078	29·000	N.-W.	N.-W	Wind moderated a little; heavy rain.	……
20	·402	·240	N.-W.	W.-S-W.	Wind moderating and blowing a hard gale. Rain decreasing.	19 to 20 ho wind mod ting slightly, still blowing hurricane fo Squalls not q so terrific.
22	·652	·570	N.-W.	S.-W.	Strong wind; rain nearly ceased.	20 to 22 ho wind mode to hard gale. heavy squalls 22 hours to night, wind derated to moderate gale occasional squa

DATE AND HOUR.	PRESSURE AT		WIND AT		WEATHER EXPERIENCED AT	
	Light House.	Port Office.	Light-House.	Port Office.	Light-House.	Port Office.
24	29·732	29·730	N.-W.	S.-W.	Wind decreasing. Drizzling rain.	Strong breeze, weather cloudy and fine.
4 A.M.	...	·690	...	N.-W.	......	Light winds, cloudy and fine.
5 A.M.	...	...	...	...	Weather clearing up.	...

The barometric observations are charted in plate XVIII.

These two accounts are very interesting and enable the position of the centre to be fixed in the afternoon of the 5th

Passage of the calm area over the Light-House at False Point.

The central calm area passed over the Light-House between 4-5 and 4-45 P.M., and hence lasted 40 minutes. As the storm was progressing at the rate of nearly 9 miles an hour, the greatest diameter in a north and south section was between 5 and 6 miles. The Port Office was just on the outer western edge of the calm centre. The Port Office bears north-north-east (*vide* Taylor's Directory) from the Light-House. As the storm was advancing in a direction between north-east and east-north-east at this time, a simple mathematical calculation shows that under the given circumstances, *viz.* that the Port Office is 6½ miles to the north-north-east of the Light-House, and the calm area passed centrally in a north-east direction over the Light-House, the Port Office would be just without the calm centre. Hence the data are in full accordance and indicate that the centre of the calm area passed over, or very near to, the Light-House.

Inferences from the observations taken during the storm at False Point.

These observations throw light upon several interesting features of cyclones. The following are the most noteworthy points :—

First.—The passage of the calm central area over the Light-House lasted more than half an hour, and hence afforded ample time to test the pressure and air motion conditions in and near the calm area. The calm lasted from 4-5 P.M. to 4-45 P.M. As described by the observer, the wind, which was blowing a moderate gale at 4 P.M., fell to a dead calm at 4-5 P.M. The transition was hence abrupt, but less so than is usually indicated by the remarks in the logs of ships that have passed through the central calm area of cyclones. The dead calm was followed by light variable winds until 4-45 P.M., after which the wind increased very rapidly and was blowing with hurricane force at 5 P.M. These observations hence indicate that the transition from the central calm to the hurricane winds just outside the central calm area is less rapid than is usually supposed, and that the change is rapid and gradual, rather than abrupt and spasmodic. This is further confirmed by the observations at the Port Office, which, as already stated, was on the edge of the calm area. The wind was blowing a violent hurricane at 3-30 P.M. It decreased rapidly at 4-12 P.M., and from 4-15 P.M. to 4-45 P.M it blew a moderate breeze. At 5-0 P.M. (when it was blowing a hurricane at the Light-House) the Port Office had only a strong breeze. The wind increased to a hard gale at 5-30 P.M., and at 5-40 P.M. it was blowing with hurricane force, accompanied with most terrific squalls. The interval between the setting-in of hurricane winds at the Light-House and Port Office was hence 40 minutes. This, taken in connection with their relative distance, enables the velocity of the storm at this stage to be estimated. This gives a velocity of 9⅜ miles per hour, which coincides almost with the estimated average velocity of the previous 24 hours. It is hence a further proof (if any were required) of the care and accuracy with which the observations were taken.

Second.—The Light-House observations indicate that pressure was lowest in front of the calm centre at a distance of about 2 miles, as the lowest pressure (28·012″) was observed at 3-45 P.M., whereas the dead calm did not commence until 4-5 P.M.

The pressure also gradually increased from north to south across the longest diameter of the calm area.

The following gives the reduced observations :—

HOURS.	Barometer reduced to 32°.	……	Weather Remarks.
3-30 P.M.	28·180	……	Hurricane winds.
3-45 „	·012	2 miles from calm area.	……
4-0 „	·084	¼ mile from calm area.	Moderate gale.
4-15 „	·122	……	Dead calm.
4-30 „	·166	Centre of calm area passing.	Light variable.
5-0 „	·180	Just outside calm area (about 2 miles.)	Hurricane winds.

One possible explanation of these changes is that the centre was filling up at this time. This appears, however, to be negatived by the fact that the pressure at 5-0 P.M. at the Port Office outside the calm area (28·19″) was almost identical with that recorded (28·18″) at the Light-House, just before and immediately after the calm central area passed over it, and also by the fact that the pressures in the calm central area on the following morning between 1 A.M. and 2 A.M., as observed on board the F. L. V. *Canopus* and the S. *Lena* were nearly as low as those registered at the Light-House. It hence appears to be more reasonable to assume that the barometric readings in question indicate real variations of pressure at the same instant in and near the calm central area than that they were due to a slight partial filling up of the central depression during its passage over the land between False Point Light House and Port Office. On this assumption pressure was in this cyclone, when passing over False Point, lowest just in front of the calm area and increased along the longest diameter from north to south in the calm central area and was nearly a sixth of an inch higher just outside the calm area in the rear than in the front.

Third.—The observations show that excessively steep gradients obtained near the centre. Thus pressure at the Light House fell ·372″ between 2 P.M. and 2-30 P.M. and ·302″ between 2-30 P.M. and 3 P. M. The fall was most rapid between 2 P.M. and 2-30 P.M. or about two hours before the arrival of the calm centre. As this fall corresponded to the space passed over by the centre and storm in that time, the fall of pressure of ·372″ occurred over a distance of about 4½ miles. The rate of fall of pressure with distance where the gradients were steepest was hence almost certainly a tenth of an inch per mile. The observations at the Port Office give the greatest all as ·180″ which occurred between 3-45 P.M. and 4 P.M. and hence very nearly corresponded to the preceding, allowing for difference of position with respect to the centre. The most rapid increase of pressure occurred at the Light-House between 5 P.M. and 6 P.M. The rise was ·301″ between 5 P.M. and 5-30 P.M. and ·310″ between 5-30 P.M. and 6 P.M. Hence the greatest and most rapid fall of pressure occurred about 2 hours before the passage of the centre, and hence at a distance of nearly 18 miles in front of the centre, and the most rapid rise about one hour after the passage of the centre. The rate of greatest fall was considerably greater (nearly 25 per cent.) than the most rapid rise in the rear.

The previous are the most important conclusions from the data as to the distribution of pressure in the immediate neighbourhood of the storm centre.

The Light-House keeper sent the following report of the damage done by the storm at False Point:—

Damage due to storm at False Point.

"The pucca buildings escaped with but slight damage, but all the fences and thatched buildings are either unroofed or levelled to the ground. The Light-House stood the storm well and the only damage is a little plaster off some of the windows. The gardens are spoiled, and three windows of the Assistant's quarters together with the front compound door, were blown off their hinges. Most of the trees are stripped more or less of their branches and some blown down. The centre of the storm passed over at 4 P.M., the calm lasting 45 minutes. The force of the wind at 12-30, when the anemometer was blown away, was 70 miles per hour after which the wind blew with hurricane force. The direction of the wind du the passage of the first half of the cyclone was from east-north-east to south- and from the latter north-west. The amount of rainfall during the passage of storm was 7·02 inches. The water rose above the height of the bunds, so t the swamps are full, and whatever damage the sluice or bunds have sustai cannot yet be ascertained."

The False Point Port Officer added the following remarks to t observations which he forwarded :—

"I would also beg to say that this has been one of the most severe cyclo that I have experienced during my long residence of 26½ years at False Poi In fact, with the exception of the cyclone of September 1885, it has been the m severe, and fortunately for us the centre, which must have been very close, passed low water, otherwise, I am afraid, we should have had a sadder tale to tell. A is, the whole of the station, except the refuge building, is in ruins, but I am happy say that no lives have been lost.

"The whole of the beacons marking the harbour have been blown away a Reddie Head Sand Spit has entirely disappeared. Yesterday afternoon I pull across in my boat what used to be dry sand and found nothing less than 6 feet water.

"I noticed that during the approach of the storm the pointer of the aner oscillated a good deal, jumping up and down fully one-tenth of an inch, and t same thing occurred when the storm was receding, but during the time the stor was passing it remained quite steady." At one time during the approach of t storm the pointer went as low as 28·08" with the oscillation. I have noticed a slig oscillation of two or three hundredths of an inch in other cyclones, but never such an extent as in this one."

Observations of the storm at Shortt's Island.

The Light-House keeper of the Light-House on Shortt's Island the entrance to the river Dhamrah (and in Lat. 20°47′ N. and Lon 86°50′ E.) took a most valuable series of observations during the stor The station was about 16 miles to the north of the centre when neare to it, and hence within the inner storm area of hurricane winds—

DATE AND HOUR.	Barometer reduced to sea-level and constant gravity.	WIND.		Direction of cloud movement.	Weather.
		Direction.	Velocity in miles per hour.		
	″				
4th, 8 A.M. .	29·826	N.-E. by E.	...	...	Blowing a moderate gale wit light rain.
10 ,, .	·812	N.-E. by E.	32		
4 P.M. .	·682	N.-E. by E.	37	...	Fresh gale, light rain.
5 ,, .	·700	N.-E. by E.	49	...	......
10 ,, .	·620	N.-E. by E.	...	...	Squalls, very frequent and vio lent.
5th, 4 A.M. .	·572	N.-E. by E.	...	N.	......
6 ,, .	·636	E. by S.	44	N.	......
8 ,, .	·678	E.-N.-E.	32	N.	Blinding rain.
11 ,, .	·588	N.-E.	40	N.	Terrific squalls.

Date and Hour.	Barometer reduced to sea-level and constant gravity.	Wind.		Direction of cloud movement.	Weather.
		Direction.	Velocity in miles per hour.		
	″				
5th, 1 P. M.	29·510	E. N. E.	48	N.	...
2 "	·480	N.-E.	40	N.	Terrific squalls with hard rain.
3 "	·396	E. by S.	61	N.	...
4 "	·340	E. by S.	64	N.	...
5 "	·218	E. by S.	...	...	5 to 10 P. M., hurricane with incessant heavy rain.
6 "	·138	E. by S.	...	...	
7 "	·040	E. by S.	...	...	
8 "	·028	E. by S.	...	...	
9 "	·050	E.-S.-E.	...	...	
10 "	·150	E.-S.-E.	...	...	
11 "	·410	N	...	...	
Midnight	·500	N	...	...	
6th, 2 A. M.	·540	N.-N.-W.	...	...	
4 "	·592	N.-N.-W.	...	...	
8 "	·732	N.-N.-W.	...	...	

Account of the storm at Shortt's Island by the Light-House Keeper.

The following is the account of the storm received from the Light-House Keeper:—

"*November 3rd.*—There was nothing in the appearance of the weather until noon of the 3rd to lead me to suspect that boisterous weather was approaching. At that hour a bank of black cloud began to form to the southward, the remaining portion of the sky being cloudless, but at 5 P.M. the sky was entirely overcast with fracto-cumulus cloud, which, at sunset, turned a dark dirty red, and then the weather rapidly assumed a threatening appearance. At 9 P.M. the first rain squall of moderate force struck the station from N.-E., which was followed by others of less strength until 11-0 P.M. From 11-0 P.M. to midnight there were no squalls, and in fact the weather cleared, looking fine all round, except between N.-,N.-E.-,E. and S.-S.-E., where it had a threatening appearance.

"*November 4th* —From 0-10 to 3-30 A.M. rain squalls became frequent, weather looking very dirty; 3-30 to 6-0 A.M. blowing a moderate gale with light rain from N.-E. 7-40 to 8-0 A.M. a strong squall with hard rain, wind hauled a point to the eastward. From 8 A.M. to noon the weather cleared somewhat, but soon after became very wild-looking, and from 1-0 to 2-30 P. M. squalls frequent and increasing in violence wind steady, fresh gale; 3-0 to 4-0 P.M. fresh gale, light rain, scud driving very fast; 4-0 to 5 P.M. no change in the weather. All persons on the island took refuge in the tower. From 5-0 to 6-0 P.M. weather again became squally with rain, wind increasing; 6-0 to 7-0 P.M. strong gale, squalls increasing in frequency and violence; 8-0 P.M. no change in the weather; 8-0 to 10-0 P.M. squalls very frequent and violent; 10 A.M. to midnight no change."

"*November 5th.*—From midnight to 6-0 A M. the squalls continued with unabated force and frequency, but the rain was not heavy during this time. During a lull which occurred between 6-0 and 6-10 A.M. the wind shifted to E. by S., followed immediately by a terrific rain squall. At 6-40 A.M. wind backed to N-E. During the lulls after the squalls the wind veered to E-N-E. and backed to N-E. on the approach of the next squall. 8-0 A.M. no change in the frequency or violence of the squalls; blinding rain prevailing. Between 8-0 and 9-0 A.M., after the squalls the clouds broke to windward, and after this the sky again became entirely overcast and squalls increased in violence; wind still unsteady. From 11-0 to 11-10 A.M. the sun shone brightly, the interval being between two squalls; afterwards the sky became overcast and very wild-looking, and squalls more violent with heavy rain. At noon I noticed that the sea-level had fallen about 4 feet in the space of about half an hour; no apparent change in the weather. From noon to 3-0 P.M. squalls one after the other in quick succession of terrific violence with hard rain. At 3-20 P.M. wind shifted to E. by S., squalls still most terrific. From 4-0 to 5-0 P.M. the appearance of the weather was most terribly wild; all persons took refuge in the light-house at this time. From 5-0 to 10-0 P.M. a hurricane from E-S-E. with incessant heavy rain and lightning; 10-10 P.M. weather suddenly moderated to fresh breeze, but gusty. At 10-50 P.M. the wind shifted to N., blowing a very strong gale but gusty with light rain and lightning. Barometer rising rapidly and pumping very much. Midnight no change."

"*November 6th.*—At 0·45 A.M. wind shifted to N.-N.-W.; no change in the weather, lightning vivid. 2-30 A.M. wind moderating in force, rain moderate. 3-0 to 4-0 A.M. wind and weather moderating, fresh gale, vivid lightning, no rain. 4-0 to 5-0 A.M. weather moderating, moderate gale, lightning not so vivid, no rain. 5-0 to 6-0 A.M. clouds broke to the S.-E., weather moderating quickly, fresh breeze, fine. *Daylight,* observed that the cups of the anemometer had blown away during the night, the instrument having stopped at 323·2 miles; all the other instruments in good order, but very dirty."

"The violence of the storm was such as to shake the light-house visibly; a great portion of the iron roof of a godown was torn off and hurled away about 100 yards into the sea; doors of the dwelling-houses were torn off at their hinges, and the mound on which the houses and godowns are built was ploughed up by the rain. The island was inundated by the sea to within 5 yards of the toe of the mound."

The preceding discussion has given a series of positions of the centre of the cyclone during the day—

DAY.	HOUR.	POSITION OF CENTRE.			Distance passed over.	Rate of motion per hour.
			Latitude, N	Longitude, E		
			° '	° '		...
5th	4 A.M.	50 miles east of Gopalpur.	19 25	85 40	...	...
	8 A.M.	15 miles east of Puri	19 45	86 5	35 miles .	8·8
	4.20 P.M.	False Point . .	20 20	86 47	65 miles .	7·8
	9 P.M.	20 miles east of Shortt's Island.	20 45	87 15	32 miles.	6·9
6th	2 A.M.	Sandheads . .	21 15	88 4	63 miles.	12·6

6th November. (Plate XIII.)

6th November.—The barometric changes of the previous 24 hours were irregular in character and small in amount, except in the area affected by the advance of the cyclonic storm. Pressure was increasing more or less rapidly in the centre and north of the Bay, and, in Orissa and Ganjam, and was falling rapidly in Bengal, more especially East Bengal, towards which the storm was now advancing.

Weather conditions in India.

The various observations indicate that the centre had continued to recurve slowly during the night of the 5th, and at 8 A.M. of the 6th it was crossing the coast of the Sunderbunds some distance to the east of Saugor Island and marching in an east-north-east direction.

8 A. M. observations at land stations in the storm area.

The following gives the 8 A.M. observations at stations in and near the storm area :—

STATION.	BAROMETER.			WIND.		Cloud proportion.	Rainfall in past 42 hours.
	Actual reduced to sea-level and constant gravity.	Change since 8 A.M. previous day.	Variation from normal.	Direction.	Average velocity in miles per hour.		
	"	"	"		"		
Gopalpur . . .	29·712	+·205	—·109	N.-N.-W.	8	1	*Nil.*
False Point. . .	·768	+·197	—·154	W.	9	8	7·02
Shortt's Island . .	*·769	+·058	?	N.-N.-W.	9	7	8·50
Saugor Island . .	·650	—·127	—·279	N.-N. W	27	10	3·18
Calcutta . . .	·722	—·107	—·211	N.-N.-E.	18	10	0·49
Jessore . . .	·757	—·080	—·142	N.-E.	8	10	0·15
Dacca . . .	·820	—·062	—·100	N.-E.	7	10	0·10
Silchar . . .	·888	—·033	—·038	Calm.	1	10	0·12
Chittagong. . .	·823	—·054	—·097		2	10	0·11

* Reduced to 32° F. only.

Skies were now overcast over the whole of Bengal and Assam and also in South Bihar and Chota Nagpur. They were partially clouded on North Bihar and the eastern districts of the North-Western Provinces, and were clear over the whole of North-Western and Central India.

Very heavy rain had fallen in Orissa during the previous 24 hours. The following gives the largest amounts registered at 8 A.M. of this day for the previous 24 hours :—

DISTRICT.	Station.	Date.	Amount in inches.
Puri . .	Puri	5th . .	13·61
	False Point	6th . .	7·02
	Gop	6th . .	14·00
Cuttack . .	Jagatsingpur	6th . .	6·30
	Kendrapara	5th . .	6·21
	Kendrapara	6th . .	9·50
Balasore. .	Chandbali	6th . .	7 92

The following statement gives an analysis of the rainfall of the previous 24 hours in Bengal, Orissa and Ganjam :—

DISTRICT.	Average rainfall of previous 24 hours.	Heaviest rainfalls in district in previous 24 hours
	Inches.	Inches.
Madras (East Coast North) .	0·02	
Orissa	3·18	100 at Gop. 9·50 at Kendra-para. 7·92 at Chandbali. 7·02 at False Poitn.
Bengal (South-West) . .	0·60	
Do. (East) . . .	0·38	
Do. (North) . . .	0·36	
South Bihar	0·06	
Chota Nagpur . . .	0·14	

Position and character of storm at 8 A.M.

The chart giving the 8 A.M. distribution of pressure of this day (Plate XIII) shows that the storm centre at that hour was due east of Saugor Island, at a distance of between 30 and 40 miles.

The observations appear to indicate that the storm was already beginning to break up. Strong winds were blowing at Saugor Island and Calcutta, nearest to the centre. These stations occupied the same position at this time relative to the centre that Gopalpur had done about 24 hours previously. The winds at these stations at 8 A.M. were very much feebler than at Gopalpur, their velocity being not more than one-half or one-third that at Gopalpur on the previous morning, when it was nearest the centre. The winds at Barisal, Dacca and Jessore in East Bengal in the north-eastern quadrant, were comparatively feeble, and Barisal reported a calm at 8 A.M. The wind directions were also somewhat abnormal.

4 P.M. observations in storm area.

The disintegration of the storm proceeded rapidly during the day. The following gives 4 P.M. observations at seven stations, the 8 A.M. observations of which are given in the preceding table :—

STATION.	PRESSURE (4 P.M.).			WIND.		Cloud propor-tion.	Weather.
	Actual reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity 10 A.M. to 4 P.M. in miles.		
	"	"	"				
False Point .	29·743	+·699	—·080	E	?	10	Overcast.
Shortt's Island *	·637	+·074	?	N	15	9	
Saugor Island .	·710	+·047	—·108	N. N. W.	26	9	Very ugly.
Calcutta .	·704	—·015	—·116	N. N. W.	12	10	Overcast.
Dacca .	·689	—·092	—·122	N. N. E.	11	10	Gloomy.
Silchar .	·781	—·038	—·022	Calm	1	10	Overcast.
Chittagong .	·707	—·075	—·110	S. S. E.	6	10	

* Reduced to 32° F. only.

. These observations indicate that the centre was a little to the south-east of Dacca. They also show that the storm was fast filling up, and that it was now a very shallow diffused depression of little importance.

Light winds prevailed at Chittagong and Silchar and moderate winds at Dacca. Skies were overcast over the whole of Bengal with the exception of the northern districts, and light to moderate rain was falling in South and East Bengal.

Advance of storm across the Sand-heads on the early morning of the 6th.

The preceding observations have shown that the storm centre at 8 A.M. was about 35 miles to the east of Saugor Island and at 4 P.M. was a little to the south-east of Dacca. As it had passed over False Point between 4 P.M. and 5 P.M. of the preceding afternoon, it advanced across the north-west angle of the Bay during the night. The light vessels and pilot vessels and a number of vessels which had arrived at the Sandheads during the previous 48 hours, and were cruising about, waiting for the bad weather to pass away in order to obtain pilots and proceed up the river to Calcutta, were all involved in the storm during the night and experienced hurricane winds and a tremendous sea.

The P. V. *Coleroon*, which had passed through nearly every cyclonic storm of the previous 20 years, foundered during the night off the Orissa coast.

The following gives an account of the weather experienced by several of the vessels which encountered the storm during the night.

The storm centre passed over the F. L. V. *Canopus* at 2-30 A.M. of the 6th. She was stationed at the *Intermediate Station* (Latitude 21° 14′ N. and Longitude 88° 11′ E.) 30 miles to the S.-S.-E. of Saugor Island.

Observations of storm taken on board the F. L. V. *Canopus*.

The following gives the barometric and wind observations recorded on board that vessel during the storm :—

DATE AND HOUR.	Barometer corrected and reduced to sea-level and constant gravity.	WIND.		Weather.
		Direction.	Force.	
5th, 6 P.M.	29·710	E.	9	Hard gale.
„ 7 „	·724	S.-E.	10	……
„ 8 „	·712	E.-S.-E.	9—11	……
„ 9 „	·706	E.-S.-E.	12	Hurricane.
„ 10 „	·684	E -S.-E.	12	Ditto.
„ 11 „	·660	E.-S.-E.	12	Ditto.
6th, Midnight	·730	E.-S.-E.	12	Ditto.
„ 1 A.M.	·490	E.-S.-E.	12	Ditto.
„ 2 A.M.	·014	E.-S.-E.	12	Calm at 2-30 A.M. Lasted for 3 or 4 minutes.
„ 2-30 A.M.	28·670	N.-W.	12	Hurricane
„ 4 „	29·400	N.-W.	9	……

Captain Beahen describes the weather he experienced as follows :—

> "On the morning of the 4th there was a moderate southerly swell, but tl wind was unsteady, veering from north-east to east, and the weather lookin very threatening and squally to the south-east; during the day the wind increase to a fresh easterly gale, and the sea became heavier.
>
> "The 5th commenced with a brisk easterly gale and high sea, but as the da advanced the wind increased in force, the sea became more confused, and the blin ing heavy rain squalls more frequent. By 4 P M. it was blowing a hard gal wind veering from east to east-south-east in the squalls, and at 10 P.M. it had settl and remained steady at east till 2-30 A.M. on the 6th, when it suddenly fell calm, tl calm lasting not more than from 3 to 4 minutes. At this time the wind shifted su denly into the west-north-west and blew with terrific force. In all my experience the Sand-heads during the last 16 years, I have never seen anything like the hea rain, thunder and lightning, terrific sea and force of the wind that we experienced this storm.
>
> "From 10 P.M. on the 5th to 3-30 A.M. on the 6th it was blowing with mo terrific force, and the sea very high and confused. At 2-20. A M., just before tl centre passed over us, the vessel heeled over to starboard, putting main and oth hatches in the water. We then parted a 20-inch coir cable, and were driven fro our station. We remained in the above position, vessel heading east-south-ea till 3-30 A.M.; the terrific sea sweeping over us. When it moderated I broug the vessel up, and at daylight found myself near the South Channel, being miles south-west off my station. I observed a number of wrecks of vessels floati about bottom up, and in pieces, and the sea covered with wreckage.

Advance of storm centre over F. L. V. *Star*.

"The storm centre also passed over the F. L. V. *Star* statione at the *Lower Gasper Station*, Lat. 21° 26′ N., Long.′ 88° 6′ E., abo 10 miles from the *Intermediate Light Ship*. The captain sent in tl following report of the storm :—

> *4th.*—"Wind E.-S.-E. to east and squally. Force 6 to 8.
>
> *5th.*—"Wind easterly and squally. At 9 P.M. a very heavy squall from ea with torrents of rain (which may be taken as the commencement of the hurrica following a few hours after). Squalls increased in violence until midnight, t which time a terrific hurricane had developed itself with a dangerously heavy s running.
>
> *6th.*—"The hurricane continuing with unabated fury until 6 A. M., when sea a wind commenced to moderate. About 3 A.M. of the 6th the calm centre pass over the vessel, the calm lasting about 10 or 15 minutes, after which the wind fl into north veering to north-west. At 10-30 P.M. of the 5th the ship parted fro her coir cable, but was brought up with the second anchor and 90 tons cable co after drifting off her station about 2½ miles."

Observations of storm of ship *Lena*.

As already stated, the ship *Lena* passed through the eastern qua rant of the cyclone on the 3rd. She continued on the 4th and 5th i advance on a northerly course up the Bay, and had strong breeze with occasional squalls and rain and very unsettled weather. At P.M. of the 5th, she sighted the Mutlah Light vessel (60 miles sout east by east from Saugor Island). At 7 P.M. she sighted the Easte

Channel Light vessel and anchored at 8 P.M. 2 miles to the north-west by west from that vessel. The following gives the account of the weather experienced during the next 24 hours as recorded in her log:—

Date and Hour.	Barometer.		Wind.		Weather and Sea.
	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.	
5th.	″	″			
1 P.M.	30·20	29·70?	...	...	Strong breeze with rain squalls.
9 P.M.	...	...	...	...	Wind increasing; sea getting up.
10 P.M.	Barometer falling.		...	...	Wind increasing in violence, sky having a wild appearance; 10 P.M. to midnight, all sails top gallant mast and yards blown clear away. High cross sea running and breaking over the vessel, ship dragging.
6th.					
0-30 A.M.	28·70	?	...	...	......
1 A.M.	28·35	?	...	...	Wind increased to hurricane; sea and sky literally mingled together. Decks one mass of water and wreckage. The wind shifted suddenly to the north and west causing the ship to lay right over the starboard side. Weather getting worse with a fearful appearance, expecting every moment the ship to take the ground as she was still dragging. At last the Captain ordered the foremast to be cut away, and this eased the ship and undoubtedly saved all on board.
1-15 A.M.	28·00	?	W.	12	Wind coming in irresistible gusts in rapid succession and roaring fearfully.
1-30 A.M.	...	?	...	...	Barometer beginning to rise a little.
2 A.M.	28·35	?	...	...	Wind appearing to ease a little.
3 A.M.	28·70	?	...	...	......
3-30 A.M.	29·00	?	...	...	Wind abating.
4-30 A.M.	29·30	?	...	...	Wind blowing a strong gale.
5-30 A.M.	...	?	...	...	Sky clearing slightly.

This vessel was just outside the calm central area which passed a little to the north of the vessel. It will be seen that it fully confirms the account of Captain Beahen as to the excessive violence of the storm.

The readings of the aneroid on board the *Lena* on the early morning of the 6th are almost certainly wrong. The observations appear to indicate that the *Lena* did not pass through the calm centre, but must have been very near to it, as she experienced the most violent winds which are described as coming "in irresistible gusts in rapid succession." She was nearest the centre between 1 A.M. and 2 A.M., nd the lowest recorded reading at 1·15 A.M. is given as 28·00″. The reading at 1 P.M. of the 5th is undoubtedly nearly half an inch too high. The lowest reading was probably nearly correct or a little too low, but it is not possible to suggest what it should be. The vessel was probably in the eastern quadrant at midnight and passed into the southern quadrant, and hence encountered the strongest winds in the inner storm area.

Storm observations of the ship *Anne Main*.

The ship *Anne Main*, after passing through the eastern quadrant of the cyclone on the 3rd, advanced northwards towards the Hooghly, and encountered the full strength of the storm on the night of the 5th and early morning of the 6th. The following extract from her log shows fully the character of the weather she encountered on the night of the 5th:—

DATE AND HOUR.	POSITION.		BAROMETER.		WIND.		State of sea.	Weather.
	Latitude, N.	Longitude, E.	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.		
4th.			"	"				
4 A.M. .			29·75	29·82	S.-E.	...	...	......
8 A.M. .			29·78	·85	E.	...	...	Weather very gloomy and overcast with ugly appearance.
Noon .	E. Channel Lightship bearing W by N. about 12 miles.		29·74	·81	E.	...	...	......
2 P.M. .	...	...	...	...	...	...	...	Anchored about 6 miles from Eastern Channel Lightship.
4 P.M. .	...	...	29·68	·75	...	...	...	Fresh gale with hard rain-squalls.
8 P.M. .	...	...	29·73	·80	...	8	High ..	Strong wind with very hard rain-squalls.
Midnight.	...	...	...	...	E.-S.-E.	9	...	Heavy rains and vivid lightning.
5th.								
4 A.M. .	...	...	29·66	·73	...	...	Less sea	Very gloomy and overcast with less wind.
8 A.M. .	...	...	29·66	·73	...	...	Less sea	Dark and threatening with less wind.
Noon .	About 15 miles from Lightship		29·50	·57	S.-E.	...	...	Wind freshening and coming in strong gusts and squalls of rain.
1 P.M. .	...	...	...	...	S.-E.	...	High and rising.	Strong gale from south-east, sky, having a wild and threatening appearance.
4 P.M. .	...	...	29·40	·47	...	...	...	......

DATE AND HOUR.	POSITION.		BAROMETER.		WIND.		State of sea.	Weather.
	Latitude, N.	Longitude, E.	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.		
			"	"				
6 P.M. .	...	...	...	...	...	...	High .	Very hard gale with heavy rain.
8 P.M. .	...	...	29·26	29·33	...	...	Increasing sea.	Wind increasing. Hurricane with terrific squalls of wind and blinding rain. Wind beginning to back to the east.
11 P.M. .	...	...	·00	·07	N.-E.	...	...	Blowing a whole hurricane with squalls of terrific force and blinding rain. Lightning flashing in sheets of vivid flame and much thunder. Wind abeam and ship unmanageable lying with leeside under water. Ballast shifted. Squared the yards to ease the ship. Found it necessary to cut away the mizenmast and main-top gallant mast and all gear. Mizen lay across the rail doing much damage.
Midnight.	...	...	28·80	28·87	N.	...	...	Hurricane seemed to reach its highest degree of violence; ship drifting at the mercy of the gale. During this terrific burst the ship lay over very dangerously with leeside under and deck full of water. Sea literally falling in heaps around us. Afterwards beginning to take off barometer, having reached to 28·80". First rise of barometer about midnight one-tenth; afterwards going up rapidly.
6th.								
2 A.M. .	...	...	29·30	29·37	W.-N.W.	...	Sea falling quickly.	Wind taking off and squalls lessening in violence.
4 A.M. .	...	...	29·50	·57	S.	8	...	Gusty weather; still overcast and cloudy.
8 A.M. .	...	...	29·70	·77	S.	4	...	Fine.
Noon .	20° 3′	87° 42′	29·70	·77	S.	2	...	Fine and clear
4 P.M. .	...	...	29·72	·79	N.-W. by N.	2	...	Fine.
8 P.M. .	...	...	29·76	·83	N.-N.-W. ½ N.	2	...	Fine.

The *Anne Main* was near the Eastern Channel Lightship at noon of the 5th. The barometer began to fall quickly at 8 A.M. and winds increased rapidly, and at 8 P.M. was blowing a hurricane. She continued to experience hurricane winds until about 1 A.M. of the 6th. The squalls are described as of terrific violence, and the lightning unusually vivid. The lowest reading of the barometer was 28·87″ at midnight. She passed rapidly from the west through the south to the eastern quadrant of the storm between midnight and 4 A.M., but was apparently at some distance from the centre at that time.

The logs of the *Lena* and *Anne Main* show a very rapid improvement of the weather in the early morning of the 6th, due in part to the commencement of the disintegration of the storm as it approached the coast.

Advance of storm over S.S. *Lincolnshire*.

The S. S. *Lincolnshire* passed through the inner storm area on the early morning of the 5th. The account of the storm as given in log is as follows :—

DATE AND HOUR.	POSITION.		Barometer actual.	WIND.		Weather.
	Latitude, N.	Longitude, E.		Direction.	Force.	
5th.			″			
4 A.M. . .	...	...	29·78	E.	6	Moderate gale; heavy rain squalls; sea confused.
8 A.M. . .	...	...	·78	E. by S.	...	......
Noon . .	20° 58′ (by account).	88° 15′	·70	E. by S.	...	......
4 P.M. . .	...	...	·68	S.-E.	...	Strong increasing gale and very heavy rain squalls. Barometer falling steadily, heavy confused sea. 4·30 P.M. Squalls becoming more violent.
8 P.M. . .	...	...	·60	S.-E. by S.	...	Strong increasing gale, heavy confused sea.
10 P.M. . .	...	...	·45	S.-E. by S.	...	Gale increasing and sea getting more confused.
6th.						
Midnight . .	...	...	·40	S.-E. by S.	...	Heavy gale and fierce rain-squalls, wind veering to S.
1 A.M. . .	...	...	·30	...	...	Terrific rain squalls.
1·30 A.M. . .	...	...	·10	S.-S. E.	...	Blowing a hurricane with terrific rain squalls.
2 A.M. . .	...	...	28·95	S.	...	Shipped tremendous sea.
2·30 A.M. . .	...	...	29·00	...	...	Wind slightly easier.
3 A.M. . .	...	...	·10	S.-W.	...	Weather slightly improved, very heavy confused sea and terrific rain-squalls.

Date and Hour.	Position.		Barometer actual.	Wind.		Weather.
	Latitude. N.	Longitude. E.		Direction.	Force.	
4 A.M. . .	...	...	29″·25	S.-W.	...	Less wind and squalls less fierce.
6 A.M. . .	...	...	·40	W.	...	Wind and sea moderating.
7 A.M. . .	...	...	·50	...	...	Clear weather.
Noon . .	...	...	·55	...	...	Sighted East Channel L.-V.
4 P.M. . .	...	...	·60	N.-N.,-W.	2	......

The S.S. *Lincolnshire,* as the *Lena,* was in the eastern quadrant at midnight and passed into the southern quadrant before 3 A. M. The probable correction of her barometer is —·09″. The lowest reading during the storm corrected was 28·86″. She was hence at some distance from the calm centre (5 to 10 miles), but experienced a hurricane, with terrific rain squalls when nearest.

The S.S. *Saint Regulus* was 10 miles south of the Eastern Channel Light vessel at noon of the 5th. The weather she experienced during the night of the 5th is given in the following extract from her log:—

Advance,, of storm over S.S. *Regulus.*

Date and Hour.	Wind.		Weather.
	Direction.	Force.	
5th.			
4 A. M.	E. S.-E.	8	Fresh gale and hard squalls with very heavy rain.
8 A.M. .	E.-S. E.	6	Strong breeze and heavy rain.
Noon .	S.-E.	7	Moderate and high cross sea.
4 P.M. .	S.-E	8	Fresh gale and high cross sea from S.-W. and S.-E.
8 P. M.	S.-S.-E.	8	The same weather as before.
6th. Midnight .	S.	12	Gale increasing to hurricane. Sea very high.
1 A.M. .	...	...	Passed the centre of the cyclone. Barometer steady Squalls very hard and very heavy rain.
4 A M. .	W.-S.-W.	9	Strong gale and high cross sea.
5 A.M. .	...	...	Gale moderating, sea going down.
8 A.M. .	W.-S.-W.	7	Moderate gale and cloudy.
Noon .	W. S.-W.	6	Strong breeze.

The observations of the S. S. *Regulus* are unsatisfactory, as they do not give the readings of the barometer. She was in the eastern quadrant at midnight and probably passed through the calm area a little south of the centre into the southern quadrant.

Observations of storm of S.S. *Japan.*

The S.S. *Japan* passed through the inner storm area at a distance of from 20 to 30 miles from the storm centre—

Date and Hour.	Barometer, actual.	Wind.		Weather.
		Direction.	Force.	
5th.	"			
4 A.M.	...	E.	...	Hard squalls with continuous rain.
8 A.M.	30·00	E.	...	Fresh breeze.
Noon	29·98	E.	...	Cloudy. Hard squalls, and high sea from E. S.-E.
1 P.M.	...	S.-E.	...	Hard squalls and continual heavy rain. Sea rising.
3 P.M.	...	...	...	Eastern Channel light vessel 7 miles N.-N.-W. Stood S.-E. by S., as there was not sufficient water to enter the river.
6 P.M.	·70	S. S.-E.	...	Overcast.
8 P.M.	·50	S. S.-E.	5 to 6	Sea high, light vessel visible.
10 P.M.	·50	S. by E.	6 to 7	Sea heavy.
6th.				
Midnight	·20	S		......
2 A.M.	·25	S. S.-W.	10 to 11	......
2-20 A.M.	·20	S.-W.	10 to 11	......
2-45 A.M.	...	...	...	Barometer jumping.
3 A.M.	·23	...	...	Ditto.
3-15 A.M.	·25	...	...	Wind veering.
3-45 A.M.	·25	...	...	Wind veering to westward gradually.
4 A.M.	·40	W. S.-W.	8	......
5 A.M.	·50	W.	6 to 7	......
6 A.M.	·60	W.	5 to 6	......
6-20 A.M.	·68	W.	4 to 5	Weather moderating and clearing.

Observations of storm of ship *Bann.*

The ship *Bann*, which encountered the storm on the 3rd, again passed into the storm area on the night of the 5th. Her observations, given below, show that she did not enter within the inner storm area of winds force 10 to 12.

Date and Hour.	Position.		Barometer actual.	Wind.		Weather.
	Latitude, N.	Longitude, E.		Direction.	Force.	
5th.			"			
4 A.M.	...	...	29·80	S.-S. E.	4	Moderate breeze with rain.
Noon	19° 48′	90° 49′	...	S.-S. E.	6	Strong breeze, squally with rain.
4 P.M.	...	...	·70	S.	...	Very hard squalls with rain.
8 P.M.	...	...	...	S.	6	Very strong breeze and bad squalls.

DATE AND HOUR.	POSITION.		Barometer actual.	WIND.		Weather.
	Latitude N.	Longitude, E.		Direction.	Force.	
6th.						
3 A.M.	...	...	...	...	9	Strong gale sprang up suddenly with heavy sea from south-west. Barometer falling very fast.
4 A.M.	...	...	29·60	S. by W.	9	Do.
8 A.M.	...	...	...	S.	9	Very strong gale and heavy sea, with furious squalls and rain.
Noon	21° 09′	89° 44′	...	S.-W.	...	Gale and sea still very heavy.
4 P.M.	...	...	·74	W	7	Gale moderating and sea going down.
8 P.M.	...	...	...	W. by S.	2	Light breeze and cloudy.

Observations at Saugor Island.

Saugor Island was about 45 miles to the north of the centre of the storm when it was nearest to that station. The following gives a summary of the observations taken by the observer at that station during the storm:—

HOUR.	Barometer, corrected and reduced to sea-level and constant gravity.	WIND.		Lower clouds moving from	Condition of sea.	Weather.
		Direction.	Velocity in miles per hour.			
5th, 8 A.M.	29·777	E.-N.-E.	15	...	...	Drizzling.
11 A.M.	·759	E.-N.-E.	...	S.-E.	Rough.	......
2 P.M.	·681	E.	16	S.-E.	Rough.	......
5 P.M.	·677	E.-N.-E.	18	E. S.-E.	Slight.	Squally.
8 P.M.	·613	E.-N.-E.	16	...	...	Squally with rain.
11 P.M.	·563	E.-N.-E.	21	E. S.E.	...	......
6th, 2 A.M.	·497	E.-N.-E.	39	...	...	Squally.
5 A.M.	·518	N.	77	...	...	Raining.
8 A.M.	·650	N.-N.-W. N.	... ?	...	Rough.	......
11 A.M.	·713	N.-W.	24	N.-W.	...	Fine weather with passing clouds.
2 P.M.	·693	N.-N.-W.	28	N. N.-W.	Slight.	

The centre was nearest to Saugor Island in the early morning, probably between 5 A.M. and 8 A.M., but as the storm began to fill up during the night of the 5th, the lowest pressure was observed between 2 A.M. and 5 A.M. The 8 A.M. distribution of pressure and the wind directions, as shown in the chart of the day, establish that the centre crossed the coast of the Sunderbunds about 30 or 40 miles east of Saugor Island between 7 A.M. and 8 A.M.

The following observations, taken on board the S. S. *Canara* lying at anchor in the river near Saugor Island, give fuller data of the weather during the night of the 5th than the preceding observations, and are interesting as showing that the storm appeared to fill up rapidly between 3 A.M. and 8 A.M., during which time the distance of the storm centre from Saugor Island ranged between 30 and 50 miles.

DATE AND HOUR.	Barometer reduced to sea-level and constant gravity.	WIND.		Weather.
		Direction.	Foce.	
November 5th.	"		...	Fresh breeze and cloudy overcast weather.
4 A.M.	29·72	E.	...	Light breeze and overcast. Occasional slight rain.
8 A.M.	77	E. N.-E,		
Noon	·73	E. by N.	...	Moderate breeze and overcast.
4 P.M.	·68	E. by S.	...	Moderate breeze and cloudy overcast weather, Rain.
8 A.M.	·70	E. N.-E.	...	Steady Moderate rain and moderate to light breeze, and overcast.
10 P M	·67		...	Squally with rain; moderate strong breeze, raining throughout; overcast and cloudy.
11 P.M.	·62		...	......
6th. Midnight	·58	E. by N.	...	......
1 A.M.	·56		...	1-15. fresh gale blowing with force; squalls at times accompanied with driving rain.
2 A.M.	·51		...	2·30, strong gale with very heavy squalls and much lightning.
3 A.M.	·46		...	Shift of wind N.-N.-E. and at 3.30 A.M. to north.
4 A.M.	·49	N. by W.	...	Strong gale with heavy squalls at times.
6 A.M.	·58		...	......
8 A.M.	·66	N.-N-W.	...	Thick gale and cloudy.
Noon	·68	N.-W.	...	Fresh breeze and fine clear weather.
4 P.M.	·73	N.-W.	...	......
8 P.M.	·80	N -W.	...	Moderate falling breeze and fine.

Account of the storm as observed by Mr. Elson near Saugor Island.

The following account of the storm as observed by Branch Pilot Mr. Elson, a most careful observer of the phenomena of cyclonic storms, is given *in extenso*:—

"At 7 A.M. of the 4th of Noemberv we started down the river bound for the Sandheads on board the S.S. *Dalhousie*, with an unpromising aspect aloft in the sky, which was gloomy and lowering; the cloud forms every now and then assuming most fantastic arrangements. There were mare's tails, mackerel sky, tufts of cumuli, and lines of stratus, all jumbled up in confusion. The cloud form struck me as ominous of stormy weather, more especially the long straight, lowish outshoots from the darkening jumble running nearly N. and S., jagged like the backbone of a herring, a form often seen before hailstorms. The rapid changes seen to take place showed plainly that the air currents were in active motion up above. A cool damp easterly wind was blowing. At Budge Budge we were somewhat startled to see No. 5 weather signal hoisted. The weather aloft seemed to be growing worse as we proceeded rapidly down the river. Still, on we went down south, passing Diamond Harbour and Mud Point, at both of which the storm signals were displayed, and the air had grown damp, while now and then a spitting of rain was brought along with the fresh N.-E. wind now blowing.

"On nearing Saugor Roads we found four large steamers at anchor, whom the storm signals had evidently detained (the No. 8 signal was by this time shown), among which was the P. and O. steamer *Bengal* bound for England. We also anchored there, but at the time, from the total absene of any breakers on the sands, or on the beach, the small wind force, and high barometer, we began to think that perhaps the weather at the head of the Bay was not so bad as to justify No. 8 storm signal, but still from former experience of the correctness of the signals hoisted by the Calcutta Meteorological Office, we waited patiently the course of events' watching the barometer, wind force and direction, and also the movements of the cloud strata aloft, which always showed the true cyclonic nature, each higher strata coming more and more from the right of the surface wind direction. But at 5 P.M. our interest in the storm received a fresh impulse, for the storm signal No. 8, which indicates a storm passing inland below False Point, was hauled down, and No. 3 hoisted, meaning that a severe cyclone was passing inwards between False Point and Saugor. This we knew meant mischief, but we had to make the best of a bad bargain, and so prepared the vessel for some hard riding. There was some vivid lightning to the northward and eastward at 7—8 P.M., and ever since we anchored it had rained, with a N. E. wind, which was only of moderate force, yet the sky denoted much wind aloft and all round seawards.

"Thursday, the 5th, at daybreak the sky looked very wild, but still very little swell such as the very ugly sky seawards would lead one to look for. The wind during the day veered from N. N.-E. to as far as E. by N. in the driving rain squalls, and all day long the same No. 3 signal remained hoisted at Saugor Light House signal station.

"A somewhat remarkable and sudden shift of wind took place at 7 P.M. The wind which had been about N. E. all at once blew in a vicious S. E. squall with heavy rain and lightning, and after about 15 or 20 minutes it suddenly fell calm for about two hours; it then freshened and blew in hard gusts from N. N. E. while vivid flashes of lightning lit up the heavy pall overhead. The barometer fell two-tenths during these hard puffs. These backings and veerings of the wind certainly pointed to eddies in the storm system, which have not been made clearly evident by any laws of storms yet brought forward. Probably they indicate a sort of double or twin whirl.

"Friday, 6th November, the wind gusts and heavy rainfall which prevailed from 11 P.M. to 1 A.M. gradually abated, so that by 8 A.M., with wind N. by W. strong, with long low lanes of driving cumuli and rack, the breaks and rifts which I observed in the S. W. had made sure way up towards the zenith, and the sun came out in all its glory, drying up the decks and all the wet awnings, while the heavy, well defined, olive coloured cyclone bank shrank rapidly inland into smaller and smaller dimensions, settling down in the N. E. quadrant.

"At noon, the weather having cleared up nicely, with moderate N. N. W. wind we weighed and proceeded slowly down Saugor Roads. At about 2 P.M. there arose a suspicious bank out of the S. E., which at one time made us think we were in for a repetition of last night's hard weather, and thought of going back again to Saugor; but just then, making out that the Lower Gasper Light vessel was off her station and at anchor near the Gasper Sand, Captain Samson went to the light vessel's assistance, and towed her into position at 7 P.M.

"Saturday, 7th November, at 6 A.M. we arrived at the Pilot station and I got on board the *Fame* Pilot vessel, which vessel was clean swept with nothing standing and no boat. The *Resolute* towed the Eastern Channel Light-vessel into position, which had driven about 6 miles S. E. off her riding station. This vessel experienced the wind at E. S. E., but it suddenly shifted to W., and blew a hurricane, parted the cable, and threw the vessel on her beam ends, so as to drown all her live stock. The Intermediate Light-vessel was, like the Lower Gasper driven in a S. W. direction, but she picked herself up 17 miles away, while this vessel, the *Fame*, not more than 10 miles west of the Eastern Channel I perienced first a N. E. and easterly winds to S. E. The ship *Matterho* at anchor near the E. C. light, awaiting orders, drove to the W. N. W. a Eastern Sea reef, but is all safe."

Weather at Chittagong on 5th and 6th.

The following account of the weather experienced at Chi on the 5th and 6th was received from the Port Officer:—

"The weather for the two previous days had been suspicious, sky over from time to time drops of rain fell, but no showers and the wind vee south to east. On the morning of the 6th the wind was from south-east at heavy bank of cloud rose to the south-west, but dispersed towards dayli the wind became gusty with slight showers of large drops of rain. T continued throughout the day from the south-east, and a few smart s rain fell. In the afternoon the weather became clearer and wind moder at 7 P.M. a heavy shower of rain fell, the wind backed to the east, and heavy gusts which increased in intensity until 1 A.M. of the 7th when the gradually cleared.

"A heavy swell from west-south-west came up on the 6th outside No damage was done here."

"The following table gives the actual and reduced readings of the b at various times throughout the day (6th):—"

Hour.	Actual.	Actual, reduced to sea-level and constant gravity.
	"	"
8. A.M.	29·990	29·823
10 A.M.	·960	·793
11 A.M.	·920	·753
Noon	·890	·723
4 P.M.	·870	·703

Inference from the preceding observations.

The preceding observations show that the storm centre the north-west angle of the Bay during the night of the 5th, an morning of the 6th, and passed into Bengal between 7 A. 8 A.M. of the 6th. It thence advanced in an east-north-east tion across South Bengal, and at 4 P.M. was about 40 miles sou of Dacca. It has also been shown that the storm filled up during the day. This was, as might be expected, accompani a rapid improvement in the weather over the whole Bay area a large decrease in the general indraught of southerly humi in the south of the Bay to the storm area in Bengal.

Weather in the Bay of Bengal on the 6th.

The following gives 8 A.M. observations taken on board vessels in the Bay on this day:—

Ship.	Position.		Barometer.		Wind.		Sea.	Weather.
	Latitude.	Longitude.	Actual.	Corrected & reduced to sea-level and constant gravity.	Direction.	Force.		
	° ′	° ′	″	″				
S. *Glenricht*	11 15	90 9	...	...	S. S. W.	1	...	Fine clear weather.
S. *Garnet Hill*	11 45	94 45	...	...	S.	1	Smooth.	Passing showers.
S. *Eurydice*	12 0	91 0	...	...	S.	1	...	Fine.
S. S. *Ursa*	13 30	85 0	...	...	N. W.	2	...	Clear.
S. *Loudon Hill*	15 30	93 0	...	...	E.	5	...	
S. S. *Wildcraft*	15 40	85 20	...	...	S. W.	2	...	Clear.
S. *Joseph*	17 5	92 10	...	...	S. by W.	1	...	Squally.
S. S. *Ironopolis*	18 20	84 20	...	...	Variable	1—2	...	Cloudy.
S. S. *Lowada*	19 25	90 45	30·00	29·80	W. by S.	4	...	Fine, occasional rain in afternoon.
S. S. *Plassey*	19 45	87 45	29·48	·75	W. N. W.	6	North swell.	Sea and wind decreasing.
S. S. *Shahsada*	20 5	89 7	...	...	S. W.	5	...	
S. S. *Waverley*	20 5	88 30	?	...	W. S. W.	5	West swell.	Squally.
S. *Kalakana*	20 9	89 38	29·78?	...	S. S. W.	...	...	
S. S. *Congella*	20 20	88 10	29·78	29·58	W. N. W.	...	...	
S. S. *Kistna*	Diamond Harbour.		29·66	...	N.	5	...	Squally.
S. S. *Maharaja*	At Kulpee.		29·80	...	E. N. E.	5 to 8	...	Strong squalls.
S. S. *Canara.*	Anchored off Saugor Island.		...	...	...	...	...	
Lincolnshire.	Near E. Channel.		29·53?	...	W.	...	...	Clear at 7 A.M.
F. L. V. *Canopus*	...	...	29·70	29·64	...	5	South swell.	Gloomy, rain 4 P.M.
F. L. V. *Star*	...	...	29·70	...	...	7	...	
S. S. *St. Regulus*	Near Sandheads.		...	...	W. S. W.	8	...	
S. S. *Japan*	Near Sandheads.		29·90	29·70	S. E. by S.	...	...	
S. S. City of Vienna.	25 miles S. W. of Intermediate F. L. V.		...	...	N. W.	7	High sea.	

The preceding data establish that light southerly winds (force 1 to 2) prevailed over the south and centre of the Bay at 8 A.M. of the 6th. South-west winds of indraught to the storm area were blowing in the north of the Bay. The strongest winds reported were of force 7 to 8 in the north-west angle of the Bay, where winds were almost certainly strongest. Hence at 8 A.M. winds increased in force from 1 in the south of the Bay to 8 at the head of the Bay. At 4 P.M. winds in the north-west of the Bay had decreased to force 4 to 5 (moderate to strong breeze).

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Weather was squally in the morning over the north of the Bay but rapidly improved in the afternoon, and fine weather, with clear skies, was reported by the great majority of vessels during the night of the 6th. The following extract from the log of the *Shahzada*, proceeding from Port Blair to Calcutta, and which reached Saugor Island on the evening of this day, shows the weather in the north-west of the Bay during the day:—

Date.	Hour.	POSITION.		Barometer actual reduced to sea-level and constant gravity.	WIND.		WEATHER.
		Lat. N.	Long. E.		Direction.	Force.	
		° ′	° ′	"			
November 1891. 6th .	4 A.M.	...	...	29·77	S. S. W.	5	Increasing wind and sea; sky overcast. Threatening appearance to N. W. to W. 4-30 A.M. Heavy squall from S. W. Sea increasing very rapidly.
	8 A.M.	20 05	89 07	...	S. W.	5	
	Noon	20 28	88 42	...	W. S. W.	5	
	4 P.M.	...	...	·85	W.	3	Fine weather with fresh breeze.

7th November. (Plate XIV.)

7th November.—During the previous 24 hours pressure had increased generally in the Indian area by amounts not exceeding ·05". In North-Eastern India these changes had been supplemented by the changes due to the advance of the storm and to its gradual filling up. Pressure had hence increased very rapidly in South and West Bengal and Orissa and had fallen slightly in Assam, Cachar, and Upper Burma.

Weather in Bengal and Cachar at 8 A.M.

The depression was at 8 A.M. in the Cachar district of Assam and adjacent districts, but it was now very slight and of little importance. The following gives 8 A.M. observations at stations in and near the depression:—

STATION.	BAROMETER.			WIND.		Cloud, 8 A.M.
	Actual reduced to sea-level and constant gravity.	Change in last 24 hours.	Variation from normal.	Direction.	Average velocity in miles per hour.	
	"	"	"			
Chittagong	29·882	+ ·059	— ·042	Calm.	5	10
Kendat	?	— ·076	?	Calm.	1	10
Sibsagar	·898	— ·048	— ·092	N. E.	2	10
Silchar	·844	— ·044	— ·085	Calm.	1	10
Dhubri	·884	+ ·023	— ·079	N. E.	15	1
Dacca	·878	+ ·058	— ·045	W. N. W.	10	10

The central disturbance was now at or near Silchar, but the depression was small in amount, probably not exceeding a tenth of an inch. Winds were very light at all the stations, and averaged only 2 miles an hour during the previous 24 hours at Silchar, Sibsagar and Kendat, and three out of the six stations reported calms. Dhubri and Dacca had experienced strong winds during the previous 24 hours, but at 8 A.M. the winds were nearly as light at these stations as at the remaining stations. At 2 A.M. and 3 A.M. of the previous day the storm was giving hurricane winds on the north-west angle of the Bay. Hence in the 24 hours preceding 8 A.M. of the 7th during which the storm had passed across the sea-face of the Sunderbunds into the plains of South and East Bengal, the vigorous cyclonic circulation had been completely broken up and the winds in the residual depression were even below the normal winds of the season in strength at 8 A.M. of the 7th. This rapid disintegration of the storm appears to have been due to two causes: —

Breaking up of the storm.

1st.—The decrease in the general strength of the southerly humid winds of indraught in the south and centre of the Bay, which had commenced at least 36 hours previously and was very marked on the morning of the 6th.

2nd.—The effect of the hills of Assam and East Bengal in breaking up a cyclonic circulation advancing towards the angle formed by them in the north-east of Cachar.

In the case of the present storm the first appears to have been the most influential cause.

The breaking up of the storm accompanied a rapid clearing up of the skies during the night of the 6th. The following gives cloud data for 8 A.M. of the 6th and 7th :—

METEOROLOGICAL AREA.	Average cloud amount at 8 A.M.		
	6th.	7th.	8th.
Orissa . . .	7	2·0	
Bengal . . .	9·5	4·4	1
Bihar . . .	5·1	0	0
Chota Nagpur . .	10	0	0
Assam . . .	1	5·5	7
Upper Burma . .	10	10	6

Skies had cleared except in Assam, East Bengal and Burma, where they were still more or less heavily clouded. Rain had fallen in moderate amounts over Burma. Assam, East and South Bengal. The following gives an analysis of the rainfall distribution during th hours preceding 8 A.M. :—

METEOROLOGICAL AREA.	Average rainfall in District during previous 24 hours.	Heaviest in trict.
	Inches.	
Orissa	0·06	0·29 i
Chota Nagpur	*Nil*	...
South Bihar	*Nil*	...
North Bihar	*Nil*	...
Bengal South-west	0·21	2·30 in
,, East	1·23	4·40
,, North	0·07	0·70

Weather in Bengal and Cachar at 4 P.M.

The following 4 P.M. observations at the stations for which 8 data have been given above show that the depression had comple filled up, and that in Cachar and the neighbouring districts of As and Upper Burma skies were clearing and light variable winds tained :—

STATION.	4 P.M. PRESSURE.			WIND.		Cloud proportion.	
	Actual reduced to sea-level and constant gravity.	in past 24 hours.	Variation from normal.	Direction.	Velocity 8 A.M. to 4. M.		
	"		"		Miles.		
Chittagong . . .	29·829	+·121	+·007	N. W.	1	6	
Sibsagar . . .	·815	—·039	—·023	N. E.	2	10	Gl
Silchar	·821	+·041	+·016	W. S. W.	1	4	
Dhubri	·809	—·001	—·018	E.	11	4	
Dacca	·824	+·135	+·010	S.	3	3	

These observations establish that the depression had almost c pletely filled up. Winds had fallen light and were beginning back to north. Thus at Chittagong winds had shifted to nc west.

Weather in the Bay of Bengal. On the 7th.

The following table gives 8 A.M. observations of the 7th taken on board vessels in the Bay :—

Ship.	Position.		Barometer.		Wind.		Sea.	Weather.
	Latitude. N.	Longitude. E.	Actual.	Corrected.	Direction.	Force.		
	° ′	° ′	″					
S. S. *Diamond* .	11 50	84 30	...	...	E.	1	Smooth.	Fine clear weather.
S. *Glenrichet* .	12 0	90 12	...	...	W. N. W.	1	...	Fine.
S. *Eurydice*. .	12 35	90 45	...	...	S.	1	...	Fine.
S. S. *Shahjehan* .	15 0	92 40	29·94	...	N. N. E.	2	...	Clear.
S. S. *Ursa* . .	17 10	86 30	...	...	N. by w.	2	Moderate swell.	Fine.
S. *Loudon Hill* .	17 30	92 15	...	...	S. W.	1	...	Clear.
S. S. *Canara* .	19 0	90 10	29·89	...	N. E.	1	...	Fine.
S. *Joseph* . .	18 50	91 35	...	...	W. S. W.	2	...	...
S. S. *Wildcroft* .	19 15	86 20	...	...	N. N. E.	2	Sea smooth.	Fine.
S. S. *Ironopolis* .	19 45	86 20	...	...	N. E.	1	...	Light variable air from 8 A.M.
S. S. *Maharaja* .	20 40	88 50	...	...	N. E.	4	Light swell.	Fine.
S. S. *Kistna* .	21 10	90 15	...	...	N. E.	4	Slight swell.	Fine.
S. S. *Kola* . .	Off Akyab.		...	...	S. W.	2	...	Fine, cloudy.
S. S. *Congella* .	Eastern Channel.		...	...	...	1	...	...
F. L. V. *Canopus* .	...	...	...	...	N. W.	3	Slight swell.	...
F. L. V. *Star* .	...	...	...	...	N.	2	Smooth.	...
S. S. *St. Regulus* .	Off Saugor.		...	...	...	1	...	Clear.
S. S. *Waverley* .	Off Saugor.		...	...	N. N W.	4	...	Fine.

These observations indicate that fine clear weather with light to moderate winds had been re-established over the Bay during the previous 24 hours. The south-west winds which prevailed over the greater part of the Bay at 8 A.M. of the previous day had given way over the greater part of the Bay area, and were already replaced by the normal north-east winds of the season. Seven vessels out of nine between Lat. 14°N. and Lat. 21°N. reported northerly or north-easterly winds. This rapid change from south-westerly to north-easterly winds in the north and centre of the Bay whilst the storm was breaking up appears to be an additional proof that the disintegration of the storm was due to the falling off in the strength of the humid winds of indraught in the south of the Bay.

CHAPTER V.

STORM OF THE 19TH TO THE 24TH NOVEMBER IN THE BAY OF BENGAL.

It appears to be desirable, before commencing the history of this storm, to give a brief statement of the normal pressure conditions of the Indian area in November and the peculiar features of the distribution of pressure in November 1891.

The second chart in Plate XIX exhibits the normal pressure distribution and direction of the lower air movement in India in November. The chief features of the former are as follows :

Normal pressure distribution in India in November. (Plate XIX.)

Pressure is highest in the North Punjab, where the mean pressure of the month slightly exceeds 30·00″ and is lowest off the Malabar and Konkan Coasts in the Arabian Sea and the south of the Bay of Bengal between the South Coromandel and East Ceylon Coasts and the Andamans and Nicobars. The mean pressure in that area is slightly less than 29·85.″ The mean range of pressure in the Indian area is hence nearly two-tenths of an inch in November. The south of the Bay is covered by a broad belt of slightly deficient pressure relatively to the equatorial belt immediately to the south of it and to the Deccan and Northern India. This broad belt is the continuation of the trough of low pressure of the monsoon period and of the month of October. It usually retreats to the equatorial belt in December, and is then absorbed into the belt of uniform pressure in that area, which marks the northern limit of the south-east trade wind area proper in the Indian Ocean.

It should be noticed that in November, as in October, pressure is fairly uniform over large areas in the Indian area. Hence the pressure variations or the abnormal features of the pressure distribution have a much larger influence in these months in modifying the pressure relations than during the previous five months of the south-west monsoon proper.

Normal air motion in India in November.

The normal air movement in the month of November is similar to that of October over the greater part of India. Light north-westerly to westerly winds prevail in the Gangetic plain and easterly winds in the Assam Valley. This air movement is continued as a southerly current, giving northerly winds in Bengal and north-easterly winds in the Bay of Bengal. In Rajputana light northerly winds obtain and in Central India and in the Central Provinces north-easterly to easterly winds. North-easterly winds prevail in the Madras Coast districts and are continued as easterly winds in the Deccan and Mysore. The air movement in India feeds into and forms an integral part of the air movement in the adjacent seas.

The movement in the peninsula forms part of the general transfer of air to the south-west which occurs over the greater part of the Arabian Sea in November as also in the northern and western portions of the Bay of Bengal. In the south of the Arabian Sea and the Bay of Bengal winds are more or less variable. Humid south-west winds, however, prevail during the greater part of the month. In the Bay these south-west winds are continued as south, south-east, east and north-east winds in the south and centre of the Bay, and hence the north-east winds in the Coromandel Coast are humid rain-giving winds. When light south-west or variable winds prevail in the south of the Bay at this time, light to moderate northerly to north-easterly winds obtain over the remainder of the Bay area.

Abnormal features of distribution of pressure and winds in November 1891 in India. (Plate XIX and XX.)

The meteorology of November 1891 was characterized by several large and well marked abnormal features, which were the continuation of similar features of the preceding month. The following gives a brief statement of the most noteworthy :—

1st—Pressure was in slight excess in the Indian land area.

2nd—Pressure was in relative defect in Northern India and Burma, and the east of the Bay, but the deficiency was generally small in amount.

3rd—Pressure was in relative excess in the peninsula, the increase being greatest in the West Deccan, South Madras and Ceylon. The following stations define the area of the greatest excess of pressure :—

Bellary	+·023"
Sholapur	+·031"
Poona	+·024"
Malegaon	+·024"
Khandwa	+·029"
Akola	+·021"

4th—The chief effects of these abnormal features were to give mean gradients during the month slightly less steep than usual, and to displace the mean position of the area of minimum pressure in the Bay. Usually it is an elongated or oval belt lying between the Coromandel Coast and the Andamans, the lowest pressure in it being near the Coromandel Coast. In November 1891, it lay between the South Coromandel and West Ceylon Coasts and the Andamans and Lower Burma. It was on the average of the month much broader than usual, especially in its eastern half and occasionally (as immediately before the cyclone under discussion) the longest diameter of this area of hallow depression ran north and south instead of east and west, its normal direction.

The axis of the trough of minimum pressure in its eastern half hence ran through the Andaman Islands instead of the Nicobars, and was hence displaced at least 5° north. A further effect of this was that the whole of the south-east of the Bay was an area of nearly uniform pressure,—a condition usually favourable for the initiation of cyclonic storms, so long as a massive humid current is blowing into the area. The mean distribution of pressure and its variation from the normal in November 1891 are exhibited in Plates XIX and XX.

5th—The air movement was in strict conformity with these peculiar abnormal pressure conditions. Winds were on the whole even lighter than usual in the Gangetic plain. In the peninsula the easterly element of the air movement was much less strongly marked. This deflection of the winds from the normal mean of the month was exhibited very strongly at the Madras Coast stations and to a slightly less extent in the Deccan and Central Provinces. The following gives data for a few representative stations :—

	STATION.	Mean wind direction, November 1891.	Normal mean wind direction, November.	Decreased easting of winds, November 1891.
Madras Coast Districts .	Vizagapatam . .	N 34° E	N 75° E	41°
	Madras . . .	N 19° E	N 61° E	42°
Deccan	Secunderabad .	N 56° E	N 53° E	3° ?
	Bellary . . .	N 75° E	N 80° E	5°
Central Provinces . .	Nagpur . . .	N 27° E	N 60° E	33°
	Khandwa . .	N 32° E	N 63. E	31°

The same pressure conditions determined an unusual prevalence of southerly and easterly winds in the eastern half of the Bay. The following gives data in illustration :—

	DIRECTION.		Increased easting.
	Mean actual, November 1891.	Normal, November.	
Port Blair . . .	S. 29° E.	N. 63° E.	...
Diamond Island . .	N. 81° E.	N. 59° E.	+ 22°
Mergui . - . .	N. 71° E.	N. 28° E.	+ 43°
Akyab . . .	N. 23° E.	N. 6° W.	+ 29°

Winds were very generally appoximately normal in strength and steadiness.

Unusually fine and dry weather prevailed during the month in North-Western and Central India. The mean temperature of the month was hence considerably in excess in North-Western India, but in the peninsula and Bay area the temperature conditions differed little from the normal.

Brief account of meteorology of India during the interval between the second and third storms.

The Port Blair cyclone filled up on the afternoon and evening of the 7th. Pressure increased over the whole of the Indian area during the next 48 hours, and on the morning of the 9th moderate gradients favouring northerly winds obtained in the Bay. During the same time skies cleared completely in North-Eastern India, whilst they became overcast in Southern India, and frequent showers fell which gave moderate general rain for some days.

On the morning of the 9th well marked anti-cyclonic conditions obtained in Northern and Central India. Pressure was highest in Central Rajputana and lowest in the south-east of the Bay and ranged at 8 A.M. between 30·12″ at Ajmere and 29·89″ at Port Blair. Pressure gave way over the Indian area during the next four days, and on the morning of the 14th it ranged at 8 A.M. between 29·96″ at Peshawar and Jubbulpore and 29·80″ at Port Blair. The Bay area was on the 13th and 14th covered by a very shallow depression, the centre of which was near and to the west of the Andamans. Skies were clear, or very lightly clouded, over the whole of India except South Madras, where they were partially clouded and rain had almost ceased to fall.

A rapid recovery of pressure occurred during the next 48 hours in Northern and Central India, whilst pressure continued to decrease in the south-east and centre of the Bay. On the morning of the 16th pressure ranged from 30·12″ at Ajmere to 29·77″ at Port Blair (thus giving a total range of pressure of ·35″). The general character of the weather remained unchanged. Fine clear weather with cloudless skies prevailed everywhere except in Lower Burma and South Madras, where skies were lightly clouded.

Weather in the Bay of Bengal antecedent to the formation of the storm.

Moderate gradients obtained in the north of the Bay, and a broad belt of low pressure lay between the East Ceylon Coast and Tenasserim. As the storm about to be described originated in this depression area, it is necessary to trace the changes of weather which occurred in it during this period. The weather charts of the 9th, 14th and 17th, published in the India Daily weather reports of these dates show the distribution of pressure, and the changes in the position of the broad belt or trough of low pressure. On the 9th it covered the south-east of the Bay, and its position and character were such that it chiefly determined humid winds, cloud and rain to Southern India. On the 14th the belt had widened out into a broad area of slightly deficient pressure, which covered the whole of the except the extreme south and with a tendency to the develop of a small central depression to the west of the Andamans. chart of the 17th shows that southerly winds were extending n wards in the eastern portion of this area of deficient pressure and the central depression had developed to some extent.

The extension of southerly winds up the east of the Bay is clearly shown by the following table giving data for Port Blair Nancowry:—

DATE.	PORT BLAIR.			NANCOWRY.	
	Wind direction at 8 A.M.	Daily air movement in past 24 hours.	Amount of rainfall in previous 24 hours.	Wind direction at 8 A.M.	Amount of rainfall in previous 24 hours.
9th .	N.-W.	96	*Nil*	Calm	*Nil*
10th .	N.-N.-E.	98	*Nil*	Calm	0·17
11th .	N.-N. E.	174	0 2	Calm	0·03
12th .	S.-S.-E.	232	0 9	Calm	*Nil*
13th .	N.-E.	308	*Nil*	Calm	0·05
14th .	E.-S.-E.	256	0·11	S.-S.-W.	0·25
15th .	Variable	373	0·66	S.	1·87
16th .	Variable	39	0·17	S.	0·85
17th .	S.-S.-E.	480	0·40	S.	0·23

The preceding data show that north-east winds obtained at Blair and calms at Nancowry from the 9th until the 13th. South winds set in at Nancowry on the 14th and blew steadily for some d afterwards. Winds were very variable, both in direction and force the 15th and 16th at Port Blair. Strong and steady south-south- winds set in on the 17th and continued for some days afterwards

The ship *Glenricht* passed through this area between the 1 and 14th on her voyage from Liverpool to Calcutta. The follow gives a summary of the weather she experienced at this time:—

DATE.	POSITION AT NOON.		WEATHER DURING DAY.
	Lat. N.	Long. E.	
	° ′	° ′	
11th .	14 24	91 7	8 A.M. A stiff squall with torrents of rain. Wind north-east before squall, but hauled to south during squall. During the remainder of the day light unst winds and showery weather.
12th .	15 29	91 3	Wind—south-east to east; light unsteady breezes cloudy showery weather.
13th .	16 21	91 40	Morning—baffling airs with heavy rain. Afternoo unsteady winds, weather dark and cloudy.
14th .	17 18	91 54	Morning—light unsteady airs. Afternoon—light north- airs and fine clear weather.

The *Glenricht* crossed the Equator on the 28th of October, and had for some days afterwards light baffling airs and calms. She advanced only 50 miles during the 24 hours preceding noon of the 29th, and her average daily run during the next fortnight was barely 70 miles. Her run during the six days preceding the 29th averaged 150 miles per diem. The vessel had very unsteady, variable winds and light airs and calms during the whole of the period from the 29th to the 14th. She experienced between Lat. 13° N. and 16° N. very heavy rain with occasional squalls. She passed into the area of steady north-east winds on the 14th, and had fine clear weather during the remainder of her voyage.

The ship *Mobile Bay*, which was dismasted by the cyclone on the 21st, crossed the Equator on the 13th and advanced into this area of heavy rain and squally weather to the west of the Andamans on the 18th. The following table gives a summary of the weather she experienced between the 13th and 17th:—

DATE.	POSITION AT NOON.		WEATHER.
	Lat. N.	Long. E.	
	° ′	° ′	
13th .	1 38	91 16	Morning—wind light from south-south-west; sky overcast; 8 P.M.—wind west-south-west and unsteady; weather very unsettled with squalls and heavy rain.
14th .	2 34	91 20	Morning—light south-west breeze and cloudy; weather squally in evening; lightning to north-west.
15th .	3 26	91 40	Wind—unsteady from south-west with heavy squalls and rain greater part of day.
16th .	No observation.		Light—unsteady south-west winds with rain squalls throughout whole day. Sea setting up from north-west.
17th .	6 8	90 57	Morning—wind south-west; north-west sea; afternoon—squalls with rain, wind hauled to west. Evening—swell from north-west; lightning to east.

The chief features of the weather experienced by the ship *Mobile Bay* in the south-east of the Bay were the continued lightness and unsteadiness of the winds and the frequent occurrence of squalls.

The S. S. *Purneah* crossed the south of the Bay between the 12th and 17th on her voyage from Penang to Negapatam. Her log is even more interesting than those of the *Glenricht* and *Mobile Bay*, as the information it contains not merely establishes that unsettled weather prevailed in the area or trough of low pressure running across the

Bay, but that weather was most unsettled in the eastern half. The following gives the whole of the information contained in her log:—

Date.	Position at noon.		Barometer, actual. 4 P.M.	Wind.		Weather.
	Lat. N.	Long. E.		Direction.	Force.	
	° ′	° ′	Inches.			
12th	6 0	96 40	29·82	Variable	0 to 1	Wind all round the compass. Torrents of rain; sea smooth. Midnight—squalls increasing and sea rising.
13th	6 25	92 45	·80	W.-S.-W.	2 to 5	8 A.M.—fresh gale; heavy banks of cloud all round. 8 P.M.—clear.
14th	7 03	90 15	·77	W. hauling to W. by N.	6 to 8	Daylight—increasing gale with hard squalls and blinding rain; high sea. Thinking the ship was running into a storm to northward, steered west and eased down. 8 P.M.—squalls less and sea decreasing.
15th	7 17	86 30	·82	W.-N.-W.	4 to 5	Morning—sea smoother; wind decreasing. Heavy clouds stacked up from N.-E. to N.-W. Afternoon—moderate breeze; swell from N.-E.
16th	9 43	82 34	·84	N.-N.-W.	4	Weather getting finer; wind going into N. and N.-N.-E. and long N.-E. swell.
17th	Arrived at Negapatam.		...	...	...	N.-E. swell. Sunset very suspicious looking.

The log of this vessel shows that the weather became more and more squally as she advanced westwards across the south of the Bay until she reached Long. 90° or 89° E., where she had a strong gale with hard squalls and blinding rain. The weather thence gradually improved and from Long. 86° to Negapatam she had moderate north-west winds with a swell from the north-east due to the disturbance in the centre of the Bay.

The various observations, hence, establish fully that during the period from the 12th to the 17th the trough of low pressure ran across the south of the Bay, and that it became gradually deeper in the eastern half to the south-west of the Andamans. Weather was very squally in this area (more especially between Long. 85° and 92°) with heavy to torrential rain.

There was a tendency to the formation of a local depression and the establishment of a cyclonic circulation in this area, but it was very feebly developed on the 17th. The storm was in the initial stage, and the unsteadiness of the winds and general character of the weather show clearly that there was as yet no definite cyclonic circulation nor central area of indraught.

The barometric changes of the next 48 hours were small in amount. The only feature of importance was the appearance of a very shallow depression in Upper Sind on the 17th. It advanced eastwards to the foot of the Himalayas during the next 48 hours and disappeared after giving a few light showers in the North Punjab and hill districts. Very light winds obtained over the whole of Northern India. In Southern India skies were very lightly clouded and rain had ceased to fall. Winds ranged in direction between north and north-west on the Coromandel Coast. The weather was, in fact, such as usually occurs during a break in the rains in Southern India due to the retreating south-west monsoon. Storms are frequently generated during such periods in the Bay of Bengal.

The preceding account has shown the gradual development of a small area of squally weather, torrential rain and of slight depression in the broad belt of nearly uniform pressure in the south and centre of the Bay during this period. We have now to trace the rapid development of this into an intense cyclone.

18th November.

Weather conditions in India.

18th November.—The pressure changes of the previous 24 hours were small and unimportant in the land area. Pressure increased in North-Eastern India and Burma and decreased in Western and North-Western India. The pressure and temperature conditions differed very little from the normal. The following gives mean variation data for the larger provinces:—

PROVINCE.	Mean variation of pressure from normal.	Variation of mean temperature from normal.	Mean hourly wind velocity in miles.	Mean cloud amount.	Average rainfall in past 24 hours.
	"	°			Inch.
Burma	+ ·008	+ 0·8	4	2·3	Nil.
Bengal and Assam . .	− ·002	+ 0·8	2	0·7	Nil.
Punjab	− ·054	+ 6·3	3	4·6	0·01
North-Western Provinces .	− ·024	+ 2·5	1	0	Nil.
Central Provinces . .	− ·008	− 0·6	2	0	Nil.
Sind and Rajputana . .	− ·041	+ 5·0	4	0	Nil.
Guzerat and Central India	− ·013	+ 2·2	3	0	Nil.
Bombay	+ ·002	− 0·5	6	1·0	Nil.
Madras	− ·004	+ 0·1	4	3·9	Nil.

The only suspicious features at this time were the absence of rain and the prevalence of abnormal north-westerly winds at the Coromandel Coast stations. The latter pointed to the existence of a depression in the centre or south-east of the Bay. The followi data for six land observatories fix its position to some extent:—

STATION.	PRESSURE.			WIND.		Cloud proportion.	Rainfall in 24 hours.
	Actual reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity during past 24 hours.		
	"	"	"				
Camorta	29·935	−·007	...	Calm.	?	10	0
Port Blair	29·848	+·051	−.060	S.-S.-E.	13	9	0
Diamond Island . . .	29·884	+·017	−·011	S.-E.	?	10	·1
Madras	29·887	−·027	−·014	N.-N.-W.	7	4	*N*
Negapatam	29·864	−·037	−·018	W.-N.-W.	6	7	*N*
Trincomalee . . .	29·860	−·014	...	N.-W.	10	4	0

These observations indicate that a shallow depression, in wh pressure was about a tenth of an inch below the normal, between Lat. 9° and 12° N. and between Long. 86° and 92° E.

Weather in the Bay of Bengal.

The following observations taken on board ships advancing nor wards up the Bay give more definite information of its position anc the character of the weather in it:—

NAME OF VESSEL.	POSITION.				BAROMETER.		WIND.		WEATHER.
	Lat. N.		Long. E.		Actual.	Corrected and reduced to sea level and constant gravity.	Direction.	Force.	
	°	′	°	′	Inches.	Inches .			
S. *Loch Broom* .	6	9	92	30	...	...	S. to S.-W.	...	Wind unsteady from s to south-west; wea very squally with tor of rain, but fine bet the showers; sea sm
S. *Mobile Bay* .	7	2	89	34	...	...	S.-W.	...	Morning—unsteady s west wind; north swell; heavy rain. Afternoon—fresh s west wind with sq and rain.
S. *Forteviot* .	7	22	90	57	...	...	S.-S.-W. to S.-W.	...	South-south-west to s west winds during continued squalls rain during the v day. Winds variab early morning; bu creased in force to a breeze in afternoon. squalls during night
S. S. *Pundua* .	7	23	91	15	29·899	29·80	S.	5	Cloudy with rain.
S. *Lyndhurst* .	9	55	89	33	...	...	S.	...	South winds with pa showers.
S. S. *Scindia* .	12	43	80	30	...	...	N.	5	Cloudy.
S. S. *Maharaja*	15	37	94	13	...	...	S.-E.	2	Heavy passing clouds rainy appearance.

The barometric and wind observations given in the above are very interesting, as they show conclusively that the available information furnish no indication of the existence, at this stage, of a regular cyclonic circulation. The whole of the observations establish that there was a shallow depression in a portion of the Bay. Winds were very light and unsteady in this area in which the storm was forming, and immediately to the south a humid south-west current was blowing towards it. The south-westerly winds were, at this stage, of moderate force, but the air was heavily charged with moisture. Squalls were, hence, of frequent occurrence, and heavy or torrential rain was falling over a portion of the area. Concentrated rainfall over a small and central portion of the depression was the only prominent meteorological feature at this time.

The marine data also establish that southerly winds had advanced up the east of the Bay as far north as Lat. 15° or 16° N., whilst north-east to north-west winds blew steadily in the western half of the Bay as far south as Lat. 7°N. These two currents from opposite directions in different parts of the Bay were practically the normal air movement of the season and not necessarily cyclonic winds in the proper sense of the word. Under favourable conditions they might become winds of indraught to a central depression and cyclonic vortex This transformation in the case of the present storm occurred during the next 24 hours.

19th November. Plate XXI.

19th November.—The chart of this day given at the end of this volume (Plate XXI) exhibits the distribution of pressure and lower air movement in the Bay area and adjacent coast districts.

Weather in the Indian land area.

Pressure had given way during the previous 24 hours over the whole of India except in North-Western India, where the disappearance of the depression had been followed by the re-establishment of the normal anti-cyclonic conditions of the period. The following gives the chief features of the pressure and temperature conditions :—

Province.	Mean variation of 8 A.M. pressure from normal.	Pressure anomaly.	Average variation of mean temperature from normal.	Mean cloud amount.
	I"	"	°	
Burma	−·0	+·002	+1·7	1·6
Bengal and Assam . . .	−·044	−·026	+0·9	2·3
North-Western Provinces .	−·040	−·022	+3·3	0
Punjab	+·024	+·042	+2 2	0
Bombay	−·001	+·017	−0·6	2·8
Berar and Central Provinces .	−·026	−·008	+0·1	0 5
Guzerat and Central India .	−·021	−·003	+1·9	0
Sind and Rajputana . .	−·010	+·008	+3·6	0 6
Madras	−·027	−·009	−0·6	3·7

The preceding data indicate that the chief abnormal features of the pressure distribution were similar in general character to those which had obtained from the beginning of October. Pressure was in excess over the whole Indian area, but was, relatively to the general condition, in defect in Northern India, Burma and the east of the Bay, and was in excess in the Peninsula and Western India. Skies were clear over the greater part of the whole area and were lightly clouded in Madras and North-Eastern India, where weather was fine and rain had ceased.

8 A.M. observations at coast stations of the Bay.

The following gives 8 A.M. observations taken at coast stations of the Bay :—

STATION.	PRESSURE.			WIND.		Cloud.	Rainfall in past 24 hours.	Weather.
	Rd uced to sea-level and constant gravity.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity in past 24 hours.			
	″	″	″		Inches.			
Port Blair .	29·851	+·003	...	S. S. E.	9	3	0·56	...
Diamond Island	29·880	+·004	—·017	S. E.	13	4	1·49	Sea rough.
Akyab .	29·898	+·031	—·030	N.	3	1	*Nil*	...
Vizagapatam .	29·871	+·055	—·069	N.	4	4	*Nil*	...
Madras .	29·870	+ 057	?	N.	10	1	*Nil*	Sea slight.
Coconada .	29·859	+·028	—·042	N. N. W.	9	4	*Nil*	...
Negapatam .	29·843	+·021	—·039	W. N. W.	3	8	*Nil*	Sea tremendous.
Trincomalee .	29.849	—·011	?	N. W.	11	9	*Nil*	...

These observations (*vide* chart of day, Plate XXI) establish that the greater part of the centre and south of the Bay was included within the isobar 29·85″ and that it was an area of shallow depression with respect to all neighbouring areas. The depression was greatest to the west of the Andamans, probably in about Long. 88° E.

Observations taken on board ships in the Bay.

The following table gives 8 A.M. observations of the day taken on board vessels in the Bay :—

SHIP.	POSITION AT 8 A M.		BAROMETER AT 8 A.M.		WIND AT 8 A.M.		Sea.	Weather remarks.
	Latitude N.	Longitude E.	Actual.	Corrected and reduced to sea level and constant gravity.	Direction.	Force.		
S. *Victoria*	° ′	° ′	Inches	Inches				
Regina .	0	88 34	...	...	S. E.	4	......	Clear.
S *Eleiser* .	0 53	91 55	...	...	S. E.	...	......	
S. *Jupiter* .	2 31	92 31	...	...	S. E.	...	......	
S. S. *Nisam* .	Tuti	corin.	30·20	29·88	S. W.	1	......	Fine and clear.

Ship.	Position at 8 A.M.		Barometer at 8 A.M.		Wind at 8 A.M.		Sea.	Weather remarks.
	Latitude N.	Longitude E.	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.		
	° ′	° ′	Inches	Inches				
S. S. *Baron Elibank* .	6 10	82 0	30·25	29·88	N. E.	2	Smooth.	Fine.
S. S. *Landaura*	7 36	77 23	29·99	29·87	S. E.	1	……	Fine and clear.
S. *Loch Broom* .	8 36	92 30	29·84	29·84	S. S. W.	…	Smooth.	Fine and clear.
S. *Mobile Bay* .	9 1	88 10	…	…	S. S. W.	5	……	Cloudy.
S. *Forteviot* .	10 25	89 53	29·62	29·83	S. S. W.	5	……	Squally.
S. S. *Katoria* .	10 27	97 16	29·94	29·91	S. S. W.	4	Moderate sea.	Dull weather.
S. S. *Scindia* .	14 13	81 13	29·87	29·85	N. by E.	… … 6	Strong head sea.	Fine weather with passing clouds.
S. S. *Kerbela* .	15 0	81 0	30·00	29·87	N. N. E.	5	Heavy E. N. E. swell.	Fine with passing clouds.
S. *Clive* .	15 40	94 0	29·93	29·86	S. E.	4	……	Clear.
S. S. *Chanda* .	16 48	92 42	30·11	29·86	S.	5	……	Cloudy.
S. S. *Fultala* .	18 16	86 34	30·05	29·88	N. N. E.	5	……	Fine and cloudy.
S. S. *Sirsa* .	at Ran	goon	29·96	29·91	Variable.	…	……	
S. S. *Japan* .	18 43	90 1	30·09	29·87	Variable.	…	……	Overcast, squally with rain.

The weather was fine over by far the greater part of the Bay. In the south of the Bay light to moderate south-easterly to south-westerly winds prevailed (except near the Madras Coast where winds were from north-west). Southerly winds had continued to advance up the eastern half of the Bay and were experienced in Lat. 15°40′ N. and Long. 94°0′ E. by the S.S. *Clive* and off the Arakan Coast in Lat. 16°48′ N. by the S.S. *Chanda*.

Moderate north-east winds obtained at the head of the Bay and off the Orissa and North Madras Coasts.

Weather was on the other hand squally in the centre of the Bay to the west of the Andamans. The ship *Forteviot* was in this area during the day and the ships *Loch Broom* and *Mobile Bay* were approaching it from the south. The following gives the whole of the weather information contained in their logs :—

Weather in the area of depression in the centre of Bay.

Name of Vessel.	Hour.	Position.		Barometer.		Wind.		State of Sea.	Weather.
		Latitude N.	Longitude E.	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.		
				Inches	Inches				
S. *Loch Broom*	4 A.M.	…	…	…	…	S. S. W.	…	Smooth.	Fine and clear.
	8 ,,	…	…	…	…	S. S. W.	…	Ditto.	Ditto.
	noon.	9°8′	92°30′	29·84	29·84	S. S. W.	…	Ditto.	Ditto.
	4 P.M. to Mid-night.	…	…	…	…	S. S. W.	3	Ditto.	Heavy rain with squalls at short intervals.

Name of vessel.	Hour.	Position. Latitude N.	Position. Longitude E.	Barometer. Actual.	Barometer. Corrected and reduced to sea-level and constant gravity.	Wind. Direction.	Force.	State of Sea.	Weather.
				Inches	Inches				
S. *Forteviot*.	4 A.M.	...	...	...	...	S. W.	5	Heavy W. N. W.	Hard squalls with rain.
	8 ,,	...	...	...	...	S. S. W.	5	...	Squalls less frequent.
	noon.	10°48′	90°16′	29·62	29·83	S. W.	4	...	Clear.
	4 P.M.	...	...	...	...	S. S. W.	4	Heavy W. N. W.	Hot, sultry weather with occasional squalls and rain.
	8 ,,	...	...	...	...	S. by E.	4	...	Similar weather.
	Mid-night.	...	...	...	...	S. by E.	4	...	Ditto.
S. S. *Mobile Bay*	n	9°1′	88°10′	...	...	S. S. W.	5	...	Cloudy.
	8 P.M.	...	...	...	...	...	...	...	Breeze increasing and becoming squally. Shortened sail.
	Mid-night.	...	...	...	...	S.	...	High N. W.	Overcast with unsteady wind.

The *Loch Broom* had fine clear weather with light south-south west breezes during the morning, but as she advanced northwards she passed in about Lat. 10° N. and Long. 92¼° E. into squally weather with heavy rain. The ship *Mobile Bay*, in the same latitude and about 300 miles to the west (in Long. 88° E.), had cloudy weather and fresh south-south-west winds in the morning. She also passed into an area of squally weather in the evening, and the character of the weather to the north was clearly indicated by the high north-west swell which she experienced during the night. The ship *Forteviot* further north in Lat. 10°48′ N. and Long. 90°16′ E. at noon had unsteady winds with changeable weather during the greater part of the day She experienced hard squalls in the early morning. At noon weather was fine and clear, but at 4 P.M. and during the night she had hot sultry weather with occasional squalls. As she advanced during the day the winds shifted from south-west to south-by-east. This veering of the wind, when taken in connection with the changeable squally weather, was significant, showing that it was probably due to a cyclonic storm in one or other of its stages and not to the ordinary recurvature of the monsoon current in November.

20th November. Plate XXII.

20th November.—The barometric changes of the preceding 24 hours were somewhat irregular, but small in amount in the Indian land area, and hence did not materially alter the distribution of pressure. The land observations also indicate that a shallow depression covered the centre and south of the Bay between the Coromandel Coast and the Andamans and Arakan Coast. Skies were clouding in Lower

Weather in the Indian land area.

Burma and had cleared in Southern India. The following variation data show that the conditions in the land area were practically identical with those obtaining on the 20th :—

PROVINCE.	Mean variation of 8 A.M. pressure from normal.	Mean pressure anomaly.	Average variation of mean temperature from normal.	Average cloud amount.
	"	"	°	
Burma . . .	—·057	—·021	+2·4	4·1
Bengal and Assam .	—·057	—·021	+0·9	1·2
North-Western Provinces	—·061	—·025	+2·1	·0
Panjab . . .	—·066	—·030	+1·1	·0
Bombay . . .	+·006	+·042	—1·3	0·2
Central Provinces . .	—·027	+·001	+0·2	·0
Guzerat and Central India	—·022	+·014	+1·1	·0
Sind and Rajputana .	—·021	+·015	+1·5	0·1
Madras . . .	—·026	+·010	—0·5	1·1

8 A.M. observations at coast stations of the Bay.

The data indicate that, whilst pressure was locally in excess in the Peninsula, it was in defect over the east of the Bay and in Burma and Northern India. The following table from 8 A. M. observation at seven coast stations :—

STATION.	PRESSURE.			WIND.		Cloud proportion.	Rainfall in past 24 hours.	Weather and sea.
	Actual reduced to sea level and constant gravity.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity in past 24 hours.			
	"	"	"		Miles.		Inch.	
Camorta . . .	29·955	—·012	?	Calm.	?	10	0·45	Dark, gloomy.
Port Blair . . .	·842	—·009	?	S. S. E.	8	4	0·81	Monsoonish weather.
Diamond Island . .	·845	—·035	—·057	E. N. E.	7	7	0·31	Sea smooth.
Akyab . . .	·861	—·037	—·070	N. E.	3	10	*Nil.*	...
False Point . . .	·894	—·013	—·070	N.N.W.	9	4	*Nil.*	Sea slight.
Vizagapatam . .	·871	0	—·070	N. N.E.	3	3	*Nil.*	Sea smooth.
Madras . . .	·862	+·003	—·040	N.N.W.	8	1	*Nil.*	...

The preceding data show the character of the weather in the coast districts. Pressure was in moderate defect, the deficiency being greatest at the eastern and northern stations. Light showers were falling in the east coast districts of the Bay. Skies were very lightly clouded on the west coast, rain had ceased to fall and winds were blowing from N. N. W. at Madras, the normal direction being N. E. to E. N. E.

Weather in the Bay of Bengal.

The following table gives 8 A.M. data of the Bay of Bengal for the 20th, extracted from the logs of vessels in the Bay on that date :—

Ship.	Position.		Barometer.		Wind.		Sea.	Weather.
	Latitude N.	Longitude E.	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.		
	° ′	° ′	Inches	Inches				
S. *Victoria Regina* .	0 58	88 42	...	...	E.	4	...	Cloudy.
S. *Eleiser* .	2 49	92 42	..	...	S.-E.	...	...	
S. *Jupiter* .	3 42	91 55	...	...	S,-E.	...	...	
S.S. *Landaura*	5 45 (Noon.)	80 31	30·00	29·88	S.-W.	...	...	Cloudy, with occasional showers
S. S. *Katoria*.	5 52 (Noon.)	99 37	29·94	29·91½	E.	2	Smooth.	Fine.
S. S. *Nisam*.	Colombo		30·20	29·88	S.-W.	3	...	Fine and cloudy.
S. S. *Khandala* . .	7 48	79 20	30·30	29·88	S.-W.	2	...	Fine.
S. *Baron Elibank* .	8 0	84 15	...	...	N.-W.	8	Cross sea from N. to N.-E.	Squally, overcast.
S. S. *Camorta*	8 49 (Noon.)	82 4	29·67	29·84	W.	4	...	Fine and clear.
S. *Loch Broom*	11 49	91 42	...	...	S.-S.-W.	...	S.-W. swell.	Cloudy and squally weather.
S. *Mobile Bay*	12 3	88 0	...	...	S.-S.-E.	...	...	8 A.M., wind blowing a hurricane.
S. *Forteviot* .	13 25	89 45	...	...	S.-E.	5	...	Hot, sultry weather.
S. S. *Scindia*.	50 miles S. of Coconada.		29·88	29·87	N.-N.-E.	6	Head swell.	
S. S. *Patialla*	Rangoon		...	...	...	2	...	Fine cloudy.
S. S. *Kola* .	Rangoon		30·04	29·86	...	...	...	
S. *Clive* .	Rangoon		29·93	29·86	Calm.	...	...	Clear.
S. *Lyndhurst*.	15 33	91 44	...	...	S.-S.-E.	6	...	Showery.
S. S. *Japan* .	15 44	92 31	30·08	29·85	S.	...	...	Cloudy, occasional squalls with rain.
S. S. *Shahjahan* . .	19 22	89 22	30·07	29·85	N.-E. by E.	4	S.-W. swell.	Cloudy.
S. S. *Kasara* .	21 35	...	29·99	29·87	N.-N.-E.	3	...	Fine, cloudy.
S. S. *Maharani* . .	Off Saugor. 15 miles		29·86	29·88	N.-N.-E	2	...	Fine.
S.S. *Bhandara*	Calcutta		30·06	29·90	...	...	...	Fine.
S. S. *Kerbela* .	Coconada		30·03	29·89	N.	4	Heavy E. swell.	Fine.
S. S. *Fultala* .	Hooghly		30·07	29·90	N.	4	...	Fine and clear.
S. S. *Chanda*.	Near Rangoon.		30·09	29·85	N.-E.	2	...	Sky clear.

These observations show that to the north of Lat. 17° or 18° N. fine clear weather prevailed. To the south of Lat. 8° N. weather was cloudy with moderate south-east to south-west winds. Between these areas was a belt in which pressure was lower than either to the north or south, and in a portion of which squally stormy weather prevailed. The data of the 19th have shown that a cyclonic storm was developing rapidly on that day in about Lat. 11½° N. and Long. 87° to 88° E. Three vessels were in the immediate neighbourhood of that central area of disturbed weather on the 20th, viz., the *Mobile Bay*, *Loch Broom* and *Forteviot*. The *Mobile Bay* passed early in the day into the central area, and encountered hurricane winds throughout the remainder of the day. The following gives the whole of the information relating to the weather she experienced on the 20th:—

Observations on board the ship *Mobile Bay*.

Hour.	Position.		Barometer uncorrected.	Wind.		State of Sea.	Weather.
	Latitude. N.	Longitude. E.		Direction.			
			Inches.				
2 A.M.	...	...	...	S.		High sea from north-west.	Sky overcast and unsteady wind.
5 A.M.	...	...	...	S.		...	Wind increasing, squally with heavy rain.
7 A.M.	...	...	...	S. S. E		...	......
9 A.M.	...	...	...	...		... ...	Heavy squall struck the ship. Rain less heavy.
Noon.	12° 3′	88° 0′	...	...			......
2 P.M.	...	...	29·20	S. E.		...	......
7 P.M.	...	...	...	S. E.		...	Main top sail blew away. Ship lying with her lee rail under water, almost on her beam ends.
8 P.M.	...	...	...	E.		...	Blowing hurricane. The main sail blew away from the yard.
11 P.M	...	...	...	N. E.		...	Blowing with hurricane force.

It should be noted that this information was obtained by the Port Officer, Rangoon, by personal enquiry. He also writes that the log was carelessly kept and that the barometer read about ·25″ below the Calcutta standard. The ship's position at noon of the 20th given in the log is Lat. 12° 3′ N., Long. 88° E. It is not stated whether this position was determined by observation or by account, but probably the latter. The extracts show clearly that the vessel passed rapidly during the day from the outer into the inner area of the intense cyclonic storm, and was carried round from the eastern to the northern quadrant between 2 P.M. and midnight. She had unsteady winds in the morning, when she was not more than 80 miles to the south-east of the centre, a strong proof that the storm area was of small extent.

Position and chief features of storm on the 20th.

The position of the storm centre at noon of the day was hence probably between Lat. 11¾° N. and 12° N. Long. and between 87½° E and 87¾° E. If the positions assigned to the centre at noon of the 20th and at noon of the previous day be approximately correct, the storm centre had commenced to move slowly in a N.-N.-E. direction during the previous 24 hours. Also, judging from the brief interval (apparently less than eight hours, so far as can be judged from the extracts) during which the winds experienced by the *Mobile Bay* increased from force 4 to hurricane force, it is almost certain that the storm proper, defined by the area in which winds were of forc or upwards, was as yet of very small diameter, and that this sı storm area now formed the central feature of a large shallow pression which had covered the centre and south-east of the during the previous four or five days.

These inferences are confirmed by the experience of *Forteviot* and *Loch Broom*. The *Forteviot* was about 150 miles to north-east of the centre at noon and advancing northwards up Bay much more rapidly than the storm. She had at that hour sou east winds, force 5, and hot sultry weather. The S. *Loch Broom* about 280 miles east of the centre at noon. She had light to moder south-south-west winds, cloudy weather and occasional rain squall

The observations hence show that the cyclone had intensified, a that it was probably extending outwards from a small central area disturbance which had formed in a large area of slight depressi Winds were light to moderate, and unsteady at distances not ceeding 150 to 200 miles in the south-eastern quadrant, usually that the strongest winds in the earlier stages of cyclonic storms in t Bay. This is confirmed by the observations at Port Blair and t Cocos' Island given below:—

STATION.		BAROMETER.		WIND.		Cloud proportion.	Rainfall in
		Reduced to 32° and corrected to sea-level and constant gravity.	Change in past 24 hours.	Direction.	Average hourly velocity during previous 24 hours.		
		"	"		Miles		Inc
Port Blair	8 A. M.	29·842	−·009	S. S. E.	8	4	o
	4 P. M.	·741	−·032	S. S. E.	8	9	o
Cocos Island	10 A. M.	·844	−·023	S.	12	4	
	4 P. M.	·752	−·033	S.	8	10	

21st November.
Plate XXIII.

21st November.—During the preceding 24 hours pressure h increased slightly over the whole of India except Sind. No impo ant change had occurred in the weather in India except in Low Burma, where the skies were now heavily clouded and modera rain was falling generally. Over the remainder of the Indian ar skies were clear, weather fine, and the air somewhat drier and coo than usual. The distribution of pressure in the land area gave ve feeble indications of the existence of the important depression in t Bay. Pressure was very uniform along the north and west coasts of t Bay, and was slightly in defect in Burma.

Weather in Indian land area.

The following table, giving pressure variation and anomaly data, shows the amount and extent of the local deficiency in North-Eastern India and Burma at this time:—

PROVINCE.	Mean variation of 8 A.M. pressure from normal.	Anomaly.	Average variation of mean temperature from normal.	Mean cloud amount.
	″	″	°	
Burma	—·043	—·011	+1·1	6·5
Bengal and Assam	—·054	—·022	+0·8	1·6
North-Western Provinces	—·022	+·010	+0·4	0
Punjab	—·041	—·009	+1·4	1·2
Bombay	—·006	+·026	—1·7	0·2
Central Provinces	—·020	+·012	—0·3	0
Guzerat and Central India	—·028	+·004	+0·4	0
Sind and Rajputana	—·055	—·023	+1·0	0·2
Madras	—·020	+·012	+0·2	1·7

The preceding data establish that the pressure conditions in the land area were similar to those of the 19th, the most important being the deficiency relatively to the normal in Burma and Bengal, and the excess in the Peninsula. The local anomalies were not large, but were sufficiently marked and permanent to indicate persistent abnormal weather conditions in the east and north of the Bay.

Weather in coast districts of Bay.

The following table gives 8 A.M. meteorological data of the 21st for eight stations on the coast of the Bay:—

STATION.	PRESSURE.			WIND.		Cloud proportion.	Rainfall in past 24 hours.	Weather.
	Actual reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity in past 24 hours.			
	″	″	″		miles.			
Camorta	29·909	—·048	?	Calm	?	6	0·24	Cloudy.
Port Blair	·799	- ·043	?	S.	16	9	0·50	Strong wind.
Diamond Island	·852	+·007	—055	E.-N.-E.	8	10	0·80	
Akyab	·861	0	—·074	E.	5	10	0·64	
False Point	·902	+008	—·066	N.	10	5	*Nil.*	
Vizagapatam	·891	+·020	—·054	N.	4	4	*Nil.*	
Madras	·877	+·015	—·026	N.	7	0	*Nil.*	

These observations show that pressure was falling locally in the east of the Bay, and was rising on the north and west coasts, but the rise was very small and of little importance.

Showery weather had extended north as far as Akyab. The most significant change in the weather was the large increase in the strength of the southerly winds blowing at Port Blair.

Weather in the Bay of Bengal.

The following table gives data of the Bay area extracted from logs of ships :—

Ship.	Position.		Barometer.		Wind.		Sea.	Wea
	Latitude. N.	Longitude. E.	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.		
	° ′	° ′	Inches.	Inches.				
S. Victoria Regina	2 33	89 11	...	...	W.	4	......	Clou
S. Eleiser . .	4 58	92 57	...	.	W. S. W.	...	......	...
S. Jupitor . .	6 29	92 58	...	...	S. S. W.	...	......	...
S. S. Landaura .	6 55	82 20	30·00	29·87	N. W.	4	North swell.	Fine clea
S. S. Pegu .	7 47	72 2	29·87	29·87	Calm	...	......	Clea
S. S. *Karamania*	9 23	80 55	30·02	29·86	S. S. E.	6	Heavy sea.	...
S. Baron Elibank	9 50	87 5	...	...	...	...	......	...
S. Lapwing .	9 52	75 55	30·11	...	S. E.	1	......	Fine.
S. S. Japan .	12 44	94 34	30·08	29·85	S.	5	South swell.	Clo u occas squ
S. *Mobile Bay* .	Position not observed		...	...	N. W.	12	......	H u r can
S. S. *Patiala* .	15 7	92 30	...	...	...	...	......	Clo u hea squal
S. *Lock Broom* .	15 18	91 16	...	...	S.	...	......	Dull.
S. S. *Shahzada* .	15 45	94 55	30·01	29·79	N. E.	2	......	....
S. S. *Shahjahan* .	16 31	91 43	29·90	29·85	E. S. E.	4	High swell.	Clou
S. *Forteviot* .	16 42	89 36	...	...	E. N. E.	Unsteady	......	....
S. S. *Kerbela* .	Off Vizagapatam.		...	...	N. E. to N.	...	E-N-E. swell.	Fine clea
S. *Lyndhurst* .	17 02	91 32	...	...	S. S. E.	6	......	....
S. S. *Maharani* .	19 08	90 46	29·80	29·82	N. E.	4	Moderate sea	Hea rain squal
S. S. *Bhundara* .	30 miles to the N. E. of Vizagapatam.		30·07	29·91	N. W.	4	......	Fine.

The preceding data show that weather was unchanged in the s of the Bay, where moderate west-south-west winds prevailed. In north of the Bay winds were increasing in strength, skies were cl ing over and weather becoming squally. This extension of cl qually weather was most marked in the north-east of the Bay off Arakan coast.

Ships involved in storm during day.

The ship *Mobile Bay* was involved in the inner storm area, the S. S. *Shahjahan* and *Patiala* and ship *Loch Broom* were in outer area of the storm during the day.

Ship *Mobile Bay.*

The following gives a statement of the weather experienced by the *Mobile Bay*:—

Hour.	Barometer.		Wind.		Weather.
	Actual.	Corrected and reduced to sea level and constant gravity.	Direction.	Force,	
	Inches.	Inches.			
3 A.M.	28·5	28·9	N.	Hurricane.	Wind tore tarpaulins off hatches.
7 A.M.	28·0	28·4	N. W.	Ditto.	
10 A.M.	...	...	W.	Ditto.	
11 A.M.	27·8	28·2	W.	Ditto.	
1 P.M.	27·5	27·9	W.	Ditto.	
2 to 4 P.M.	...	...	Calm	...	Wind fell almost calm; high cross sea.
4 P.M.	27·5	27 9	S. W.	...	Gust of wind from south-west. Wind then moderated for a short time, then blew hard from north-west, increasing to hurricane force. The vessel broached to on the starboard tack about 5 P. M.

This is the whole of the information for the 21st, except that it is also stated that at 4 P.M. the indication of the aneroid barometer went past the graduation, and the captain estimated that when lowest the reading was 27·0" (corrected 27·4").

The information hence shows that the *Mobile Bay* was at the mercy of the storm throughout the day. She was carried along with it, and passed from the western to the southern quadrant of the storm and thence drifted under the force of the winds and currents into the calm centre, and was retained there for about two hours, when she was left behind, apparently in the south-west quadrant. She had hurricane winds during the whole period, except during this interval of two hours when she was in the calm centre. It is doubtful how far the readings of her aneroid are to be accepted. Aneroid barometers are by no means reliable, even under the most favourable conditions, and hence the very low reading of the aneroid (27·00") can only be accepted so far as showing that pressure was very low in the central area, and almost certainly less than 28·00"

S. S *Patiala*

The S. S. *Patiala*, which left Rangoon on the morning of the 20th was in latitude 15° 7′ N. and longitude 91° 47′ E. at noon of the 21st. She had moderate breezes and fine weather during the morning. In the afternoon the wind and sea began to increase and the barometer to fall, and at 4 P.M. the captain, judging that there was a storm in front of him in the centre of the Bay, turned his ship and proceeded slowly eastwards *during the* remainder of the day. The following extract from her log gives the weather she experienced during the afternoon and evening:—

Hour.	Barometer.		Wind.		Weather.
	Actual.	Corrected and reduced to sea level and constant gravity.	Direction.	Force.	
	Inches.	Inches.			
2 P.M.	...	...	E.-S.-E.	4 to 5	Overcast, squally with rain Wind and sea increasing. Heavy south-west swell, increasing and working to S.-S.-W.
4 P.M.	29·94	29·74	S.-E. by E.		......
7 P.M.	...	...	S.-S.-E. to S.-E. by S.	7	Moderate gale with heavy squalls and heavy S.-S.-W. swell.
9 P.M.	...	...	S.-E.		......
10 P.M.	29·96	·76	...	...	Moderate gale with terrific squalls. Lightning to N.-W.
Midnight	29·96	·76	...	...	Moderate gale with fine clear weather. Heavy S.-S.-W. swell.

S. S. *Baron Elibank.*

The S. S. *Baron Elibank* was about 150 miles to the south of the storm centre at noon. The following extracts from her log are interesting as showing the increasing strength of the in-draught:—

Hour.	Course.	Barometer.		Wind.		Weather.
		Actual.	Corrected and reduced to sea level and constant gravity.	Direction.	Force.	
		Inches.	Inches.			
1 A.M.	N.-E.	...	...	W.	9	*Morning*—violent squalls with showers. High cross sea from N. and N.-N.-E.
4 A.M.	N -E.	29·95	29·68	...	...	......
10 A.M.	...	29·90	·63	...	...	......
4 P.M.	...	29·70	·43	W.	9	*Afternoon*—violent squalls and much rain; high cross sea which got steadily worse during the day.
10 P.M.	...	29·65	·38	W.	9	......

She was proceeding from Colombo to Rangoon and hence crossing the south of the Bay. Her log is interesting as it shows the strength and steadiness of the westerly winds at distances of 150 to 250 miles south of the centre at this time, and also the increasing intensity of the storm.

The ship *Loch Broom* was 300 miles to the north-east of the centre during the morning. She had cloudy weather with heavy squalls and a heavy swell from south-west during the day. Winds were steady at south during the greater part of the day.

The S. S. *Kistna*, which left Akyab at 9 A.M. for Chittagong, had light to moderate north-east breezes during the afternoon, with overcast skies and drizzling rain in the evening.

The preceding information is chiefly interesting as showing the very rapid increase in the intensity of the storm. It is almost certain that on the 19th the storm was in the initial stage of squally weather in an area of nearly uniform pressure or of very shallow depression, and the strongest winds in or near this area did not exceed 5 in force. On the morning of the 21st there was a deep depression, at the centre of which pressure was probably more than an inch below the normal. A central calm area was in existence at 6 P.M., and hurricane winds were experienced in the inner storm area. The strongest evidence of the growth of the storm is the occurrence of winds of force 9 at distances of 150 to 250 miles from the storm centre. The data are not sufficiently numerous or precise to enable the position of the centre to be fixed with certainty. The various observations indicate that it was in Lat. 12°45′ N. and Long. 88°30′ E. at 8 A. M. It had hence probably advanced 190 miles in a north-easterly direction during the preceding 24 hours.

Chief features of the storm on the 21st.

22nd November.

Plate XXIV.

22nd November.—The barometric changes of the preceding 24 hours were everywhere small in amount and made no important change in the distribution of pressure in the land area. Pressure had increased slightly over nearly the whole of Western and Upper India and fallen in other districts. The changes were less than ·05″ at all stations except Diamond Island (—·054″), False Point (—·051″), and Roorkee (—·051″).

Weather in Indian land area.

The land observations showed that there was a depression to the south-west of Lower Burma, but gave no indications of its extent or intensity. Skies were overcast in Burma and were clouding over in East and South Bengal. They were clear in the remainder of the land area. Light to moderate rain had fallen during the previous 24 hours in Lower Burma. The following table gives the chief data:—

PROVINCE.	Mean variation of 8 A.M. pressure from normal.	Pressure anomaly.	Average variation of mean temperature from normal.	Mean cloud amount.
	″	″	°	
Burma	—·060	—·016	—2·9	7·5
Bengal and Assam	—·084	—·040	+0·7	1·9
North-Western Provinces . . .	—·064	—·020	+0·4	0
Punjab	—·056	—·012	+0·8	0·8
Bombay	—·007	+·037	—2·2	0·7
Central Provinces	—·035	+·009	—1·3	0
Guzerat and Central India . . .	—·022	+·022	—0·8	0
Sind and Rajputana	—·043	+·001	0	0·2
Madras	—·029	+·015	—1·3	0·8

Weather at coast stations of Bay.

The following statement is a summary of 8 A.M. observatic taken at seven representative coast stations :—

STATION.	PRESSURE.			WIND.		Cloud proportion.	Rainfall in past 24 hours.	Weather.
	Actual reduced to sea-level and constant gravity.	Change in past 24 years.	Variation from normal.	Direction.	Average hourly velocity in past 24 hours.			
	"	"	"		Miles.		Inches.	
Camorta . .	29'921	+'014	?	Calm	?	10	0'36	Dark, gloom
Port Blair . .	'769	—'030	—'120	S. S. W.	17	6	0'47	Squally.
Diamond Island .	'798	—'054	—'116	E. S. E.	20	9	0'37	Sea rough.
Akyab . .	'877	+'016	—'064	E.	5	10	0'47	Overcast rain.
False Point . .	'901	—'001	—'072	N.	17	5	*N*	
Vizagapatam .	'880	—'011	—'071	N. W.	3	...	*N*	
Madras . .	'880	+'003	—'028	N.N.W.	5	...	*Nil.*	

These observations show that pressure continued to give way the east of the Bay, whilst it was steady or increasing slightly in t Peninsula. The depression was hence more clearly defined by t land observations than previously. The great increase in the streng of the winds at Diamond Island and the shift of wind from ea north-east to east-south-east also indicated that the storm was a vancing northwards up the Bay. Skies had cleared over the whc of the Madras coast. Heavy rain was now commencing in Burm The following large amounts were registered at 8 A.M. :—

District.	Station.	Amount in Inches.
Thongwa .	Maubin .	3'23
	Wakema .	3'39
	Dedayè . .	3'11
Bassein . .	Labutta . .	3'40
	Diamond Island .	3'37

Weather in the Bay of Bengal.

The following gives 8 A.M. observations taken on board ships in t Bay on this day :—

SHIP.	POSITION AT 8 A.M.		BAROMETER AT 8 A.M.		WIND AT 8 A.M.		SEA.	Weath remark
	Latitude. N.	Longitude. E.	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.		
	4 '	° '	"	"				
S. *Victoria* .	∪ 3	89 17	...	...	W.	4	...	Cloudy
S.S. *Nisam* .	9 35	81 45	30'10	29'88	N.	3	...	Fine.
S.S. *Japan* .	28	96 43	30'10	29'87	S.	4	...	Fine clear.

Ship.	Position at 8 A.M.		Barometer at 8 A.M.		Wind at 8 A.M.		Sea.	Weather remarks.
	Latitude. N.	Longitude. E.	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.		
			Inches.	Inches.				
S.S. *Landaura* .	9 38	83 11	29·97	29·84	N. E.	6	N.-E. swell.	Fine and clear.
S. S. *Camorta* .	Negapatam.		...	...	N. E.	4	...	Clear.
S. S. *Shahjahan*.	13 16	93 23	29·85	29·80	S.S.E.	6	...	Cloudy and squally.
S. *Latham* .	14 38	89 30	...	...	S. E.	2	...	Fine.
S. S. *Patiala* .	15 50	93 53	29·97	29·77	S. S. E.	9	...	Finecloudy (strong gales with veryheavy squalls in evening).
S. *Mobile Bay* .	Position not given.		27·20	27·60 ?	?	12	...	Hurricane.
S. S. *Kerbela* .	Callingapatam.		30·06	29·88	N. to N. W.	4	...	Fine clear.
S. S. *Bhandara* .	17 55	83 15	30·04	29·88	N. W.	4	...	Fine.
S. S. *Lyndhurst* .	18 0	91 30	...	...	Calm	...	...	Fresh E.-N.-E. breeze in evening.
S. *Forteviot* .	18 20	89 15	29·53	29·74 ?	E.N.E.	...	...	Unsteady winds and cloudy.
S. *Loch Broom* .	18 31	89 28	...	...	E.	5	...	Squally.
S. S. *Shahzada* .	18 38	92 97	...	...	E.	8	...	Heavy rain, squally.
S. S. *Maharani* .	18 50	90 30	29·76	29·78	E. S.E.	7	High sea.	Heavy clouds.
S. S. *Sirsa* .	Near Rangoon.		29·90	29·87	N.N.W.	...	...	...
S. S. *Scindia* .	Vizagapatam.		29·90	29·88	N. E.	...	Heavy swell from N. E.	...
S. S. *Palamcotta*.	...	?	29·96	29·93	N. E.	...	...	Fine cloudy.
S. S. *Nancowry* .	30 miles S.S.E. off Sandheads.		...	...	N. E.	...	Swell from E. N. E.	...
S. S. *Comillah* .	Chittagong .		...	...	Calm.	0	...	Overcast.

These observations establish in the first place that no change had occurred in the weather over the south of the Bay and in the north-west of the Bay, where moderate winds and fine clear weather continued.

The storm area in the centre of the Bay had evidently increased considerably in extent. The various observations when charted as in the chart of the day indicate that the centre was in Lat. 14° N. and Long. 89¾° E. at 8 A.M. Assuming these positions, the steamers *Patiala*, *Shahzada*, and *Maharani*, at distances of 200 to 300 miles to the south of the centre, had winds of force 7 to 9. The outer storm area

had hence extended or expanded very considerably during the pa
hours, and the storm was now of considerable extent. The expansic
the storm area is confirmed by the observations at the nearest
stations, of which the following is a summary :—

STATION.	PRESSURE.			WIND.				WEAT
	Actual reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity in past 24 hours.	Cloud proportion.	Rainfall in past 24 hours.	
	"	"	"		Miles.		Inches.	
Port Blair .	29·769	—·030	—·120	S. S. W.	17	6	0·47	Clou
Cocos Island .	29·746	—·077	—·150	S.	?	10	*Nil*	Over
Diamond Island.	29·793	—·054	—·116	E. S. E	20	9	3·37	Sea ro

Diamond Island was 270 miles to the east-north-east and Port I
240 miles to the east-south-east of the centre at 8 A.M.

Ship *Mobile Bay.*

The only vessel which was near the centre of the storm on
22nd was the *Mobile Bay.* Her position is not given in the log
it was not possible to take any observations. She was involve
the calm centre between 2 and 4 P.M. of the previous day and
left behind in the south-west quadrant.

The following gives extracts from her log of the weather
experienced on the 22nd :—

HOUR.	BAROMETER.		WIND.		Weather.
	Actual.	Corrected.	Direction.	Force.	
5 A.M.	...	...	...	Hurricane.	Wind lulled a little, but it impossible to state the dire as lights could not be kept g
6 A.M.	...	...	...	Ditto .	Wind came in gusts. The n mast snapped off, and was sl ly after followed by the foren
2 P.M.	27·50	27·90?	...	Ditto .	......
5 P.M.	27·50	27·90?	...	...	Weather began to moderate.
9 P.M.	..	...	...	...	Barometer rising, high cross s

It is also stated in the account that the mainmast snapped
about 6 feet above the deck, but the foremast went below the d
and, as it fell, it burst up the deck. Everything was hence i
state of terrible confusion.

As no wind directions are given in the statement, it is he
not possible to state with certainty her position with respect
the storm centre during the day. It is almost certain that after
passed out of the calm centre into the southern quadrant,

drifted with the winds and current to the north-east but was gradually left behind by the storm. She was within the inner storm area during the greater part of the day and did not pass out until the evening. She had light westerly winds at 2 A.M. of the 23rd.

S. S. *Patiala.*

The *Patiala* was about 220 miles to the east-north-east of the centre and steaming slowly in a direction nearly parallel to the storm track. The weather hence became gradually worse during the day. The following gives the chief data for the day in her log:—

Hour.	Barometer.		Wind.		Weather.
	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.	
	Inches.	Inches.			
4 A.M.	29·94	29·74	S. S. E.	4 to 5	Moderate to fresh gale. Fine cloudy weather with occasional hard squalls. Heavy S.-S.-W. swell.
8 A.M.	29·97	·77	S. S. E.	...	Moderate to strong gale. Sky cloudy. Heavy S.-W. swell.
Noon	29·96	·76.	S. E.	...	Moderate gale. Heavy sea from S.-E.
4 P.M.	29·95	·75	S.E.by E.	...	Fresh gale and overcast with hard squalls and rain. Heavy S.-E. sea and S.-W. swell. Turned ship round and went W.-S.-W. until 9 P.M., when original course resumed.
8 P.M.	29·94	·74	S.E.by S.	...	Fresh to strong gale with very heavy squalls. Heavy confused sea.
Mid-night.	...	...	S. E.	...	Whole gale to storm with very heavy sea.

The centre at midnight was in about Lat. 15¼° N. and Long. 91¾°E., at which hour the *Patiala* was not more than 80 or 90 miles to the east. The fact that she experienced a whole gale to a storm at that distance from the centre is an additional proof of the large extension of the inner and outer storm areas which had taken place during the day.

S. S. *Canara.*

The S. S. *Canara,* which left Rangoon early in the morning for Calcutta, had moderate to fresh winds until 8 P.M., when the wind began to strengthen and squalls to come down. At 9 P.M., the weather looked very threatening and became rapidly worse and worse. At midnight when the ship was probably a little to the south-east of Diamond Island, she had a heavy gale from south-south-east, with a violent sea and terrific squalls of wind and rain. The captain notes that at 11-15 P.M. the Alguada light bore N. ¼ W. and was distant 12 miles. She was hence about 170 miles nearly due east of the storm centre at that hour. The following gives the whole of the meteorological information for the day in her log:—

HOUR.	BAROMETER.		WIND.		State of sea.	Weather.
	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.		
	Inches.	Inches.				
8 A.M.	29·85	29·88	S. E.	5	...	Overcast.
Noon	·84	·87	S. E.	5	...	Rain throughout.
4 P.M.	·75	·78	S. E.	4	...	Light rain at times.
8 P.M.	·78	·81	S. S. E.	6	Confused.	Passing squalls and overcast. South-east swell.
9 P.M.	·76	·79	S. S. E.	...	Sea rising.	Weather looking very threatening. Barometer falling, and weather getting worse.
Midnight	·70	·73	S. S. E.	...	...	Heavy gale, with violent sea and terrific squalls of wind and rain. Ship rolling and pitching.

Inferences from data of 22nd.

The preceding data have hence shown that the storm increased in extent during the day. The centre at 8 A.M. was in Lat. 14° W. and Long. 89¾° E., and had travelled during the preceding 24 hours at an average rate of nearly 6 miles per hour.

The increasing extent of the storm was fully shown by the logs of several vessels, and the observatories at Port Blair and Diamond Island. These observations establish that winds were of force 8 (moderate gale) and upwards at distances of at least 300 miles from the centre in the south quadrant, and to distances of 150 to 200 miles in the north and east quadrants. There were no ships in the western quadrant of the storm near the centre. The nearest were the *Bhundara* and *Kerbela* at a distance of 400 miles and near the coast of the Circars where winds were light to moderate and weather very fine and clear, the only indication of stormy weather in the Bay being a "heavy swell from the north-east." The only vessel which furnished data showing the actual intensity of the storm was the *Mobile Bay*.

23rd November. Plate XXV.

23rd November.—In the discussion of the weather of the 22nd it was stated that the centre at 8 A.M. was in Lat. 14° to 14½° N. and Long. 89¾° E., and at midnight it was in Lat. 15¼° N. and Long. 91¾° E. It had hence advanced about 170 miles during the previous 16 hours, and was hence moving with a rapidly increasing rate. Its average speed during this interval was between 10 and 11 miles per hour. The centre at midnight was 200 miles west by south from Diamond Island and was advancing in a north-east direction (N. 55° E.).

Meteorology of Indian land area.

The advance of the storm during the preceding 24 hours towards the Arakan coast had caused a large reduction of pressure in Lower Burma and Arakan. Pressure had, on the other hand, increased in the Peninsula and North-Western India, and fine clear weather, with light winds, obtained generally in that area. The wind directions at the Madras coast stations had a strong westerly component caused by the disturbance in the Bay. The air was hence unusually dry and skies almost free from cloud.

Skies were overcast in Burma, and were more or less clouded over the greater part of Bengal and Assam.

Observations at coast stations of the Bay.

The following gives 8 A.M. observations at the land observatories nearest to the storm centre at that hour:—

STATION.	PRESSURE.			WIND.		Cloud 8 A.M.	Rainfall in past 24 hours.	Weather.
	Actual reduced to sea-level and constant gravity	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity in past 24 hours.			
	"	"	"		Miles.		Inches.	
Port Blair . . .	29·819	+·050	?	W.S.W.	17	3	0·25	Squally.
Cocos Island . .	29·793	+·047	...	W.	?	10	2·77	Overcast.
Diamond Island . .	29·721	—·077	—·201	S. S. W.	32	10	3·17	Sea tremendous.
Bassein . . .	29·734	—·122	—·191	S. E.	16	10	2·83	Continuous rain.
Rangoon . . .	29·787	—·100	—·147	E. S. E.	7	10	0·83	Drizzling.
Thayetmyo . . .	29·873	—·011	—·073	N.	10	10	0·56	Continuous rain.
Akyab . . .	29·784	—·093	—·164	N. E.	7	10	1·16	......

The observations indicate that the centre was to the north-west of Diamond Island at a moderate distance (about 100 miles). Its most probable position at 8 A.M. was in Lat. 16½° N. and Long. 93° E., or at a distance of about 125 miles to the north-east of its position at midnight. Its mean velocity during the previous eight hours was 16 miles, and hence its rate of motion was still rapidly increasing.

The following gives a summary of the observations taken at Diamond Island during the storm:—

DATE AND HOUR.	Barometer corrected.	WIND.		Cloud amount.	Rainfall since last observation.	Weather.
		Direction.	Velocity during interval since preceding observation.			
	Inches.		Miles.		Inches.	
22nd, 2 P.M. .	29·715	E. S. E.	...	9	...	Wind increasing in force. Sea very rough.
8 P.M. .	·714	E.	37	10	0·03	Squalls increasing in frequency and force. Sea very rough.
10 P.M. .	·668	E.	44	10	0·02	Hurricane winds. Sea tremendous.
23rd, 2 A.M. .	·628	S. E.	39	10	0·83	Wind blowing in violent puffs; squalls of rain. Wind variable.
5 A.M. .	·640	S.	36	10	2·15	Terrific squalls; sea tremendous. Dark gloomy weather.
11 A.M. .	·747	S. S. W.	16	10	0·03	Squalls decreasing in force and frequency.
2 P.M. .	·686	S. S. W.	14	9	0·01	Sea falling.
5 P.M. .	·720	S. W.	10	10	*Nil*	Weather again getting squally.
8 P.M. .	·797	S. W.	11	3	*Nil*	Fine, with passing clouds.
11 P.M. .	·819	W. S. W.	4	3	*Nil*	Do. do. do.

The storm centre was probably due west of Diamond Island about 3 A.M., at which time it was 140 miles distant. The strongest winds were apparently experienced between 10 P.M. and 2 A.M. It is hence probable that, as the storm was now rapidly approaching the Arakan coast, the intensity of the southerly winds was beginning to diminish in consequence of having to pass in part over a land area before approaching the centre.

8 A. M. observations in the Bay of Bengal.

The following gives a summary of 8 A.M. observations taken on board vessels in the Bay :—

SHIP.	POSITION AT 8 A.M.		BAROMETER AT 8 A.M.		WIND AT 8 A.M.		Sea.	Weather remarks.
	Lat. N.	Long. E.	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.		
	° ′	° ′	Inches.	Inches.				
S. S. *Sirdhana*	2 26	82 31	30·05	29·86	Calm	...	...	......
S. *Victoria Regina* .	5 20	89 17	...	...	W.	4	...	Drizzling rain.
S. S. *Nizam* .	8 50	81 20	30·10	29·88	N.	3	...	Passing clouds.
S. *Jupiter* .	10 49	92 14	...	...	W. S. W.	...	...	......
S. S. *Camorta*	At anchor, Cuddalore.		...	...	N. N. E.	2	...	Fine.
S. S. *Landoura* . .	12 38	83 42	29·97	29·85	N. N. W.	4	Heavy N. E.	Fine and clear.
S. S. *Mobile Bay* . .	14 30	92 0	...	...	W.	2	Swell .	......
S. S. *Sirsa* .	14 6	96 45	29·90	29·87	S. S. E.	5	...	Cloudy.
S. S. *Bhandara* . .	At anchor, Coconada.		...	...	...	1	Heavy E. swell .	......
S. *Forteviot* .	18 5	89 30	...	...	N. E.	...	Heavy sea	......
S. S. *Scindia*.	At anchor, Vizagapatam		...	...	...	2	...	Fine.
S. S. *Palamcotta* . .	19 15	89 46	29·86	29·83	N., by E.	5	Heavy sea	......
S. S. *Kasara* .	Off Akyab		29·92	29·80	E. N. E.	6	Heavy sea from S. .	Constant drizzling rain.

The information of the weather in the Bay on the 23rd is very scanty. The storm was now approaching the Arakan coast, and the circulation in the south and east quadrants was impeded by the broken ground of the Arakan ranges. The observations appear to indicate that the circulation had already decreased very considerably in intensity. In the west and north-west of the Bay winds were light, and in the east of the Bay they were moderate to fresh except in the immediate neighbourhood of the storm centre, where violent winds still probably obtained.

Ship *Mobile Bay*.

The *Mobile Bay* was left behind in the southern quadrant of the outer storm area on the evening of the previous day. She was then a complete wreck on deck. The following gives the weather she experienced on the 23rd:—

HOUR.	BAROMETER.		WIND.		Weather.
	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.	
	Inches.	Inches.			
2 A.M.	28·00	28·40	...	...	Weather moderating.
9 A.M.	...	...	W.	2	Light wind; sea going down.
Noon .	28·80	29·20	...	...	Light breeze; cloudy.
1 P.M.	29·00	29·40	W.	2	Cloudy.
8 P.M.	...	...	W.	2	Cloudy Passing showers of rain.

Observations taken on the 24th showed that she was in Lat. 14° 50′ N. and Long. 92° 24′ E. Her position at noon of the 23rd was probably not more than 30 miles to the south-west.

The Port Officer, Rangoon, makes the following remarks about the state of the vessel on her arrival there:—

"The substance of the *Mobile Bay* paper is culled from the log-book by myself and is the best information that could be gathered from it. I cannot help being astonished at the miraculous escape this vessel had. She was insufficiently ballasted and must have been on her beam ends most of the time, as she sits like a cork on the water. She arrived at Rangoon with nothing but her mizen mast standing, the main mast broken off 6 feet above the deck, and the foremast about 15 feet below the deck. I think her preservation is due to the master's forethought in fitting his vessel with shifting bulkheads before ballasting her with sand, which he also saturated with water when he found he was involved in a cyclone."

The reading of the aneroid (29·00″) when she passed out of the storm into fine weather is extremely low and shows that the correction had altered considerably and, as already stated, that the readings during the storm are hence more or less unreliable. The Port Officer, speaking of the aneroids on board the *Marpesia* and *Mobile Bay*, says:

"I have to inform you that both these vessels are small and indifferently fitted out with instruments. However, as they do not appear to have made much use of them, it makes no difference. From all accounts their aneroids behaved in a very extraordinary manner and very little reliance can be placed on the readings. That belonging to the *Mobile Bay* I found "·25″ too low on comparing it with mine, which is correct with Calcutta standard. Its dial graduation commences at 27·50″, but by a remark in the log-book the indicator was about ·50 below that for some hours. I noticed a mercurial barometer in this vessel, but the master informed me that the mercury disappeared during the cyclone and had just commenced to rise again. On examination I found the instrument had received considerable injury by contact with the sky-light in which it was hung."

The S. S. *Canara*, *Patiala*, and *Comilla* were within the storm area in the morning.

S.S. *Canara*.

The S. S. *Canara* which was near the Alguada Light at midnight of the 22nd was rapidly approaching the cyclone at that hour. The captain altered his course from west to south until

8 P. M. of the 23rd, when he turned the ship and proceeded full speed. The following gives extracts from the log of the *Canara* :—

HOUR.	BAROMETER.		WIND.		Weather.
	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.	
	Inches.	Inches.			
1 A.M.	29·64	29·67	S. S. W.	...	Weather getting worse, if possible, with heavy thunder and vivid lightning to southward.
4 A.M.	·60	63	S.	...	Similar weather, seas doing more damage on deck. Vessel at times buried in seas, flooding saloon, etc. Sea from S. W.
6 A.M.	·70	73	S. to S. S. W.	...	Barometer rose from 29·65" to 29·70" in half an hour. Wind going to S. S. W. Sky dull blue grey and dense clouds to S. W.
8 A.M.	·74	77	S. to S. S. W.	...	Strong gale and heavy sea with blinding rain squalls.
11 A.M.	·78	81	...	...	Sky clearing a bit and showing blue sky with heavy squalls at times.
Noon.	·78	81	Ditto .	...	Similar weather; violent squalls of wind and rain very frequently.
4 P.M.	·74	77	...	...	Wind and sea again rising.
8 P.M.	·78	81	S. W.	...	Weather clearing and sea falling.
Midnight.	·85	86	S. W.	...	Moderate breeze and sea.

The *Canara* had very bad weather in the morning, with violent rain squalls. The weather began to clear in the afternoon and the captain hence at 8 P.M. altered his course, and proceeded full speed north-westwards across the Bay to the Hooghly. She had moderate breezes during the remainder of the night, and fine clear weather on the 24th.

S. S. *Patiala.*

The S. S. *Patiala* passed through the southern quadrant of the storm in the morning. She was proceeding from Rangoon to Calcutta and passed the Alguadas late in the preceding evening :—

HOUR.	BAROMETER.		WIND.		Weather.
	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.	
	Inches.	Inches.			
1 A.M.	...	...	S. E.	...	......
2 A.M.	...	...	...	...	Whole gale to storm with heavy squalls and rain. High cross sea and heavy S. W. swell.
3 A.M.	...	...	S.	...	......
4 A.M.	29·76	29·56	S. S. W.	...	......
5 A.M.	...	...	S. W.	...	......
6 A.M.	...	...	W. S. W.	...	......
7 A.M.	...	...	W.	...	Storm to hurricane with very heavy sea from westward.
8 A.M.	...	...	W. N. W.	...	......
9 A.M.	...	...	N. W.	...	......
10 A.M.	...	...	...	...	Wind and sea moderating; weather clearing up.
1 P.M.	...	...	W.	...	......

HOUR.	BAROMETER.		WIND.		Weather.
	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.	
	Inches.	Inches.			
3 P.M.	...	...	W. N. W.	...	Light to moderate breeze and fine cloudy weather, heavy N.-N.-W. swell.
4 P.M.	29·92	29·72	W. N. W.	...	......
7 P.M.	...	...	N. W.	...	Light breeze and fine clear weather N.-N.-W. swell and passing clouds.
8 P.M.	30·01	29·81	N. W.	...	......
11 P.M.	...	...	...	...	Light breeze and fine clear weather.
Midnight	30·02	29·82	N. W.	...	......

The S. S. *Patiala* was nearest to the centre at 7 A.M. The wind, which was at south-east at 1 A.M., veered steadily through south and south-west to west at 7 A.M., when she had hurricane winds, with a very heavy westerly sea. In consequence of the north-easterly advance of the storm and of the *Patiala* passing rapidly into the westerly quadrant, the weather improved very quickly. At 10 A.M. the wind and sea were moderating, and at 3 P.M. she had passed into fine weather with light to moderate breezes. At 7 P.M. she had fine clear weather and light north-west breezes, which continued during the remainder of the voyage.

S. S. *Comilla.*

The *Comilla*, proceeding from Chittagong to Rangoon, was in the northern quadrant of the depression in the morning:—

HOUR.	POSITION.		BAROMETER.		WIND.		Weather.
	Latitude N.	Longitude E.	Actual.	Corrected and reduced to sea-level and constant gravity.	Direction.	Force.	
	° ′	° ′	Inches.	Inches.			
4 A.M.	20 20	91 50	29·96	29·76	N. 83° E.	5	Overcast; heavy south-westerly swell.
8 A.M.	19 50	92 3	29·96	·76	N. 83° E.	5—6	Sky clear; heavy cross sea.
Noon	19 22	92 13	29·92	·72	N. 60° E.	6—7	Sky clear overhead, but large mass of light cloud on horizon. Heavy confused sea.
4 P.M.	18 48	92 30	29·90	·70	N. 47° E.	7	Heavy dark clouds to windward. Heavy sea and confused swell from S. E.
8 P.M.	18 8	92 20	29·95	·75	N. N. E.	6	Clearing to windward. Heavy sea.
Midnight.	17 31	92 18	30·01	·81	N. N. E.	5	Weather finer, wind and sea moderating.

The *Comilla* was about 100 miles to the north of the centre at 8 A.M. She had clear skies during the greater part of the day with a heavy confused sea, and fresh to strong winds. During the day the wind direction backed from east to north-north-east. Her experience shows that weather improved rapidly off the Arakan coast on the afternoon and evening of the 23rd.

4 P.M. observations at coast stations.

The following gives observations of the coast stations at 4 P.M. of the 23rd November:—

	PRESSURE.			WIND.			
	Actual reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation from normal.	Direction.	Average velocity 8 A.M. to 4 P.M. miles per hour.	Cloud proportion.	Weather.
	"	"	"		Miles.		
Port Blair .	29·758	+·057	—·147	W. S. W.	32	2	Misty.
Diamond Island	·699	—·005	—·118	S. S. W.	13	7	Cloudy.
Akyab . .	·716	—·089	—·121	N. N. E.	8	9	Ditto.
Rangoon . .	·756	—·037	—·062	S. S. E.	9	10	Ditto.

The information is very limited, as the great majority of the observatories in Burma only record 8 A M. observations. The observations show that the storm had passed inland, and that rain had ceased to fall in the Arakan coast districts. Heavy rain was falling in Lower Pegu due to the strong southerly winds blowing up the Irrawaddy Valley.

Inferences respecting advance of storm.

The data hence establish that the storm centre was due west of Diamond Island at 3 A.M., and was in Latitude 18½° and Longitude 89¾° at 8 A.M. It crossed the coast some distance south of Sandoway shortly after noon, probably about 2 P.M. or 3 P.M. Its rate of motion had increased very considerably during the previous 36 hours and it was almost certainly travelling at a rate of at least 16 miles on the morning of the 23rd. The observations indicate that it began to fill up rapidly as it approached the Arakan coast, and that it was probably of moderate intensity when crossing the Arakan hills on the afternoon and evening of the 23rd.

24th November.

24th November.—The storm centre, as has already been seen, crossed the Arakan coast on the afternoon of the previous day, nearly midway between Akyab and Diamond Island, and probably a little south of Sandoway. It was then advancing in a north-easterly direction towards the Arakan hills, which are in this part comparatively low, not exceeding 2,000 or 3,000 feet in elevation.

8 A.M. observations in storm area in Burma.

The 8 A.M. observations of the 24th show that the storm was almost completely broken up by its passage across those hills, and that it was then a very shallow and diffused disturbance, affecting the whole of Lower and Central Burma.

The following give 8 A.M. observations in that area :—

	Pressure.			Wind.			
	Actual reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity in past 24 hours.	Cloud proportion.	Rainfall in past 24 hours.
	"	"	"		Miles.		Inches.
Tavoy . . .	29·918	+·021	?	Calm	1	4	0·14
Port Blair . .	·883	+·064	?	N. W	16	2	*Nil.*
Diamond Island .	·853	+·132	—·073	W.N.W.	9	4	0·04
Bassein . . .	·862	+·128	—·071	S.	11	10	0·61
Rangoon . .	·844	+·057	—·098	S. S. W.	?	8	2·41
Tounghoo . .	·875	+·009	—·072	Calm	3	10	0·98
Thayetmyo . .	·899	+·026	—·053	N.	14	10	3·32
Mandalay . .	·930	—·033	?	N. E.	...	10	0·66
Akyab . . .	·865	+·081	—·089	N. E.	4	...	*Nil.*

These observations establish that there was a very shallow depression in Lower Burma. Pressure was apparently lowest at Rangoon, but the observations at that station have not been very satisfactory for some time, and it is doubtful whether the 8 A.M. reading of the barometer on this day is quite correct.

The air movement was very irregular as well as light, and indicated that the cyclonic circulation had completely broken up, and that the normal winds of the season continued in Upper Burma. Southerly to westerly winds prevailed in Lower Burma, a residual effect of the storm which passed rapidly away during the day.

Skies were more or less heavily clouded in Burma, and were clear over the whole of India except South Madras, where they were lightly clouded.

The storm gave moderate to heavy rain to Burma during the previous 24 hours.

The following gives a statement of the rainfall registered at 8 A.M. of this day :—

Division.	Average actual rainfall during previous 24 hours.	Heaviest Rainfall in Division in 24 hours.	
		Amount.	Station at which recorded.
	Inches.	Inches.	
Tenasserim . .	0·68	4·55	Thaton
Lower Burma . .	0·65	4·36	Kyauktan.
Central Burma . .	2·49	10·88	Myanaung.
Upper Burma . .	0·55	2·33	Pyinmana.
Arakan . . .	0·52	3·94	Sandoway.

8 A.M. observations in the Bay of Bengal.

The following table gives 8 A.M. observations taken on board vessels in the Bay on the 24th :—

Ship.	Position at 8 A.M.		Barometer at 8 A.M.		Wind at 8 A.M.		Sea.	
	Latitude. N.	Longitude. E.	Actual	Corrected and reduced to sea level and constant gravity.	Direction.	Force.		Weather Remarks.
	° ′	° ′	Inches.	Inches.				
S. *Victoria Regina*	6 30	89 17	...	...	W.	6	......	ludy.
S. S. *Khandala* .	8 30	81 45	30·34	29·91	N. W.	2	......	ne.
S. S. *Sirsa* .	11 25	97 0	29·96	29·91	E. by S.	4	......	Fine and clear.
S. S. *Clan Grant*	11 40	80 42	30·13	29·90	W	...	......	...
S. *Jupiter* .	13 30	92 0	...	...	W	...	......	...
S. S. *Landaura* .	15 37	84 54	29·98	29·86	N. E.	...	Swell from N. E.	Showery.
S. S. *Pallamcotta*	16 46	92 57	29·97	29·87	N. E.	5	......	Fine and clear.
S. S. *Maharani* .	17 44	92 1	29·84	29·86	N. E.	3	......	Clear.
S. *Forteviot* .	18 2	90 16	...	...	N. W.	1	......	Faint airs and calm.
S. *Loch Broom* .	19 30	89 32	...	...	N. E.	...	......	Fine and clear.
S. S. *Kasara* .	Off Kyoukphyoo		...	...	N. E.	2	......	Fine.
S. S. *Bhandara* .	Vizagapatam		30·10	29·94	N. E. N. N. W.	2	......	Fine; passing clouds.

These observations indicate that fine weather was completely re-established in the Bay area. Light to moderate north-east winds obtained over the greater part of the area. The S. S. *Kasara*, off the South Arakan coast, had light north-east winds, force 2, and fine weather, and the S.S. *Maharani*, about 100 miles west of Sandoway, at 8 A.M. had fine weather, with clear skies and north-east winds, force 3. The marine data hence confirm the inference, based on the land observations, that the storm had broken up rapidly during the previous afternoon and evening, when crossing the Arakan hills, and that it was transmitted across into Central Burma as a disturbance of slight intensity.

Final breaking up of storm on night of 24th.

The following 8 A M. observations on the 25th at the Burma stations establish that the disturbance had passed completely away and that normal conditions were re-established in that area :—

	Pressure.			Wind.		Cloud proportion.	Rainfall in past 24 hours.
	Actual reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity in past 24 hours.		
	"	"	"		Miles.		Inch.
Tavoy . .	29·963	+·045	?	W.-N.-W.	2	8	0·10
Diamond Island .	·940	+·087	+·011	E.-N.-E.	8	10	0·02
Bassein . .	·964	+·102	+·026	E.-N.-E.	5	8	0·01
Rangoon . .	·976	+·086	+·032	E.-N.-E.	4	10	0·22
Toungoo . .	30·001	+·126	+·050	N.	2	10	0·63
Thayetmyo .	·022	+·123	+·067	N.	5	5	...
Mandalay . .	·026?	+·074	?	N.	?	8	0·03

Burma received moderate rain during the previous 24 hours. Skies cleared during the day and normal conditions of pressure, temperature, winds and weather set in and continued during the remainder of the month.

CHAPTER VI.

DISCUSSION OF THE CHIEF FEATURES OF THE STORMS.

The preceding pages have given a full account of the three cyclonic storms in the Indian area during the month of November 1891. Some of the more important features of these storms, more especially those bearing on the theories of cyclonic generation and motion, are dealt with in the following paragraphs.

Origin and track of first of Minicoy storm.

The first storm was generated in an area of light variable winds to the west of the Malabar coast on the 31st of October and 1st of November. Light north-east winds obtained over nearly the whole of the Arabian Sea. Westerly humid winds prevailed to the west of Ceylon. Heavy rain began to fall in the area of light variable winds and a small cyclonic storm was rapidly formed on the 1st and 2nd. The following gives the approximate position of the centre from the 1st to the 3rd:—

DATE.	POSITION OF CENTRE.		Average rate of motion in miles per hour.
	Latitude N.	Longitude E.	
1st, 8 A.M	8° 0′	73° 50′	...
2nd, „ A.M.	8° 0′	73° 20′	1·8
3rd, „ A.M.	8° 15′	72° 45′	1·2

The storm centre hence advanced in a west or west-north-west direction at a rate not exceeding 2 miles per hour. As the normal direction of advance of storms off the Malabar coast at this period of the year is between west and north-west, the track of the storm was normal in character. Its low rate of motion was evidently mainly due to the fact that the storm was in the initial stage of cyclone formation, when the velocity of motion is always small. The observations of the tidal observer at Minicoy show that such cyclonic storms are of very rare occurrence at or near Minicoy and that the rainfall at Minicoy was unprecedented in amount. These facts support the inference based both on experience and theory, that cyclonic storms are almost unknown nearer to the Equator than the eighth parallel of latitude. Excessive local or concentrated rainfall was the predominant feature in this storm, the rainfall attending the storm being as exceptional as the storm itself. The observations at Minicoy are further interesting as showing that the rainfall was probably most excessive on the 31st and 1st whilst the storm was being generated, and hence that it immediately preceded and accompanied the formation of the storm.

It is very rarely that exact information is obtained of the phenomena accompanying the birth of a storm in the neighbourhood of the equator, and hence the meteorological data at Minicoy of the 31st October to the 3rd of November are especially interesting. It will be seen that they confirm the views of Mr. Blanford and myself as to the probable genesis of cyclonic storms in the Indian seas.

Port Blair cyclone.

The second storm, the Port Blair cyclone, was the most interesting of the three storms. It was a fully developed cyclone, having a calm central area, an inner storm area of very steep gradients and hurricane winds, and an outer storm area of moderate gradients and strong winds.

Track and rate of advance.

The following table gives the position and rate of advance of the storm centre at intervals during its existence from the 1st to the 6th November:—

Date.	Hour.	Place.	Position.		Distance passed over during interval.	Average rate of motion in miles per hour.
			Lat. N.	Long. E.		
			° ′	° ′		
Nov. 1st	1-30 A. M	Chaiya	9 10	99 16		
	3 A. M.	Kapu	...	...	40(?)	
	8 A. M.		9 50	97 30	150	23·1(?)
Nov. 2nd	2-30 A. M.	Port Blair	11 40	92 40	330	17·8
	8 A. M.	Mid-Bay	12 10	91 10	115	20·9
Nov. 3rd	8 A. M.	Ditto	14 10	87 20	275	1 ·5
Nov. 4th	8 A. M.	About 100 miles south-east of Vizagapatam	16 25	85 5	220	9·2
Nov. 5th	4 A. M.	50 miles east of Gopalpur	19 25	85 40	208	10·4
	8 A. M.	15 miles east of Puri	19 45	86 5	35	8·8
	4-20 P. M.	False Point	20 20	86 47	65	7·8
	9 P. M.	20 miles east of Shortt's Island	20 45	87 15	32	6·9
Nov. 6th	2 A. M.	Sandheads	21 15	87 51	48	9·6
	8 A. M.	East of Saugor Island	21 45	88 45	70	11·6

Origin of the storm in the Gulf of Siam.

The storm was fully developed on the morning of the 1st of November, when it entered the Indian area from the Gulf of Siam and Lower Siam. Its velocity in Lower Siam, as estimated by the Bangkok authorities, was 20 miles per hour, which agrees closely with its average velocity when crossing the Andaman Sea, *e.g.*, 18 miles per hour.

Nothing is known of its origin, except that it appears to have formed in the Gulf of Siam and not to have passed into that area from the China Sea. Dr. Doberck, of the Hongkong observatory, the chief authority on typhoons in the Chinese Sea, furnishes almost conclusive evidence on this point, and also adds that it is most unusual for a storm to advance from the Gulf of Siam and pass across Lower Siam and Tenasserim into the Bay of Bengal. The storm was hence probably an example of a class of storms of very rare occurrence in India, *viz.*, storms originating in the Gulf of Siam (or the China Sea), and passing thence into the Bay of Bengal as fully developed cyclones or typhoons. I have examined the lists of cyclones in the Bay of Bengal drawn up first by Mr. Blanford and continued by myself, and so far as can be judged from the meagre details of many of the earlier storms, almost certainly not more than three or four storms of this class have been recorded from the year 1737 up to the present time which may have advanced across the Malay Peninsula into the Bay of Bengal.

The following gives a brief statement of all these storms in the Bay of Bengal which may have passed into the Bay from the Malayan Peninsula, taken from the records of the Calcutta Meteorological Office.

No.	Year.	Date.	Description.
1	1840	Nov. 21st	Storm to the north-east of the Andamans.
2	1844	Nov. 9th—14th	Storms to the east of the Andamans. The troopships *Briton* and *Runnymede* were dismasted in this storm and wrecked on the Andamans.
3	1872	Oct. 24th—26th	Cyclone passed over the Island of Narkondam and the Cocos Islands. It levelled the forest on Narkondam to the ground.
4	1888	Sept. 13th—20th.	This storm crossed the Tenasserim Hills, north of Tavoy, on the 13th, and advanced across the Gulf of Martaban into the Bay of Bengal on the 14th. It thence crossed the Bay, increasing in intensity as it advanced, at an average rate of 14 miles per hour on a west-north-west track. It reached the Orissa coast on the early morning of the 16th and thence advanced by a very curved path and finally broke up on the 20th at the foot of the Punjab Himalayas.

In the case of the first and second storms the information is too brief to indicate the track of the storms. It is stated in the Bengal Meteorological Report for 1872 that the third storm which levelled the forest on the island of Narkondam formed near the Andamans, but the evidence is very slight and by no means conclusive. The fourth storm undoubtedly crossed or formed over the Tenasserim Hills as a moderately deep depression. It was of comparatively slight intensity in the Gulf of Martaban, but increased rapidly whilst crossing the Bay of Bengal, and hurricane winds were experienced in the storm area when it was approaching the Orissa coast on the night of the 15th. No information has been obtained as to the existence of a storm in the Gulf of Siam or in Siam of which this storm of September 1888 in the Bay of Bengal might be the continuation.

Hence previous to the Port Blair cyclone the evidence of the probable passage of cyclonic storms from the Gulf of Siam across the Malayan Peninsula was very slight indeed; so small in fact that in my Hand-book of Cyclonic Storms in the Bay of Bengal it is stated: " All cyclonic storms in the Bay of Bengal originate or are produced in the Bay itself."

After the experience of the storm of September 1888 and the cyclone of November 1891, it is necessary to modify this inference as follows:—

" Cyclonic storms in the Bay of Bengal almost invariably originate in the Bay, but under exceptional circumstances of rare occurrence they may enter it from the Gulf of Siam and the Malayan peninsula."

Probable conditions antecedent to and determining the formation of the cyclone in the Gulf of Siam.

It is not possible to infer with certainty from the data of one storm the more important antecedent conditions determining the formation and track of the class of storms of which it is an example. The following gives known important abnormal meteorological conditions in the Indian area which were probably related to the formation of this storm in the Gulf of Siam.

1st.—Pressure had for some time previously been locally in excess in the peninsula, the excess being greatest in the Deccan, and had been in defect in the south-east of the Bay, the Andaman Sea and Tenasserim. The following variations or baric anomalies of the month of October for representative stations in each of these two areas illustrate these remarks:—

	Station.	October Barometric anomaly.
Area of increased pressure in the Deccan.	Raipur	+·025"
	Nagpur	+·025"
	Akola	+·028"
	Cuttack	+·030"
	Secunderabad	+·010"
	Bellary	+·011"
Area of decreased pressure in the Malay Peninsula, Burma and the Andaman Sea.	Port Blair	—·016"
	Diamond Island	—·018"
	Mergui	—·032"
	Moulmein	—·029"
	Rangoon	—·026"

The preceding data show clearly the chief features of the pressure anomalies. Pressure was locally in excess in the Deccan and in defect in the south-east of the Bay, the Andaman Sea and Tenasserim, the deficiency increasing in amount eastwards and being actually greatest at Mergui. These figures hence suggest that pressure was at this time also persistently in defect in the neighbouring Gulf of Siam, and probably to an equal or greater amount than at Mergui, Hence also, as already pointed out, the trough of low pressure occupied a very abnormal position in the Bay in October. It was further south than usual and the eastern half was widened out both to the north and south and was deeper than usual. This feature was even more conspicuous in the last week of October than it had been heretofore, and the pressure anomaly charts of the 30th and 31st (Plates IV and V) illustrate its position and character at that period very clearly. The peculiar position of the broad belt of slightly deficient pressure in the Bay of Bengal, and probably the Gulf of Siam, accompanied large abnormal variations of the atmospheric circulation and rainfall of the period and was hence almost certainly a product of, and not the cause of, these variations. These are given in the following paragraphs.

2nd.—The south-west humid winds during the months of July, August and September in the south of the Bay had a much larger westerly or smaller easterly component than usual, thus showing that the monsoon current in the Bay was diverted to a greater extent than usual to the east of the Bay and Burma. The winds in the month of October in Burma and the Andaman Sea were even more remarkable than in the preceding three months. The following gives mean wind data of Port Blair, Mergui, and Diamond Island, and of three stations in the Malayan Peninsula, for which data are available :—

STATION.	MEAN WIND DIRECTION.		STEADINESS PER CENT.	
	Actual, October 1891.	Normal, October.	Actual, October 1891.	Normal, October.
Port Blair	S.69°E.	S. 5°W.	38	24
Mergui	N. 4°E.	S.79°W.	37	22.
Diamond Island . . .	N. 7°E.	S. 59°E.	26	21
Penang	S. 88°E.	N. 3°W.	24	35
Malacca	S.36°W.	S.76°W.	20	7
Singapur	S.30°W.	S.56°W.	50	26

The mean wind directions of Port Blair, Diamond Island, Mergui and Penang not only differ very largely from the normal but also indicate that the deflections from their normal directions were almost certainly due to the existence during the greater part or the whole of the month of an area of shallow depression or
pressure in the Andaman Sea and the area
Peninsula, *i.e.*, the Gulf of Siam. Hen

the [illegible]

[illegible]

[illegible] The following [illegible]

False Point	[illegible]	[illegible]
Vizagapatam	[illegible]	[illegible]
Madras	[illegible]	[illegible]

[illegible] The [illegible] Madras [illegible] The following [illegible]

Area [illegible]	[illegible]	[illegible]	[illegible]

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Cyclone resembled in important points False Point cyclone of September 1885.

The rainfall of October was considerably below the normal of the month in Lower Burma and also in the Andamans and Nicobars as represented by Port Blair and Camorta. It was, on the other hand, in moderate excess at Mergui and Penang. No information is available of the rainfall in Siam or the Gulf of Siam, but the occurrence of heavier rain than usual at Penang and Mergui indicates the existence of a strong humid current in the immediate neighbourhood of the Gulf of Siam, which might give rise, under suitable conditions, to the occurrence of the concentrated rainfall that is invariably associated with the rapid development of cyclonic storms in the Indian monsoon area.

The following table gives rainfall data in illustration of the preceding remarks :—

	Rainfall.					Total of month.	Normal of month.	Variation from normal.
	October 1st to 7th.	October 8th to 14th.	October 15th to 21st.	October 22nd to 28th.	October 29th to 31st.			
Port Blair	0·04	0·38	4·40	0·67	0·16	5·65	12·17	—6·52
Camorta	2·42	0·78	1·53	3·18	0·13	8·04	14·23	—6·19
Mergui	0·60	3·15	10·02	1·63	0·25	15·65	13·54	+2·11
Tavoy	0·89	2·25	1·97	...	0·07	5·18	10·51	—5·33
Moulmein	0·42	2·54	0·81	0·04	0·41	4·22	8·28	—4·06
Diamond Island	0·13	1·34	0·76	0·99	...	3·22	8·92	—5·70
Penang	3·82	3·84	3·28	3·87	6·55	21·36	19·32	+2·04
Malacca	0·25	0·60	0·80	0·45	0·72	2·82	7·71	—4·89
Singapur	3·85	1·12	0·30	1·14	0·28	6·69	6·44	+0·25

Hence a reference to the preceding remarks and to the data of Chapter II establish the following. Throughout the whole monsoon period, from June to September, there had been an abnormally strong determination of the monsoon current in the south of the Bay to Tenasserim and Lower Burma. It was shewn as strongly by the deviation of the mean winds of the period from their normal direction as by the increased rainfall (vide page 8). The rains ceased in Northern and Central India on the 6th and 7th of October and were followed by an even more rapid rise of pressure than usual, which was most marked in the Central Provinces, Central India and the North-Western Provinces, the areas of most excessive rainfall in September. The first and chief effect of the rapid and unequally distributed rise of pressure which followed the close of the rains in Northern and Central India was to divert the greater portion of the monsoon current to the southern districts of Madras. A partial break in the rains also set in over Burma later in the month. A portion of the humid monsoon current continued to pass eastwards across the South Andaman Sea to the Malayan Peninsula, and perhaps to the Gulf of Siam, and some portions of Tenasserim and the Malayan Peninsula hence received heavier rainfall than usual in October. The conditions from the 7th to the 25th were very persistent in the Deccan and Madras. Rainfall gradually diminished in extent and amount after the 26th, and pressure increased locally relatively to neighbouring districts. Hence the Deccan high pressure area extended southwards during the last five days of the month. This change brought into greater prominence the area of deficient pressure in the Gulf of Siam and the Andamans in one portion of the trough of low pressure and the area of deficient pressure off the Malabar coast in the Arabian Sea portion. The south-west monsoon current, which was still comparatively vigorous, undoubtedly gave heavy concentrated and torrential rain in the second of these areas on the 31st October and 1st of November, and thus initiated and generated the Minicoy storm.

It is hence very probable that the same current about the same time gave excessive and concentrated rainfall to the first and quasi-permanent depression at this time in the Gulf of Siam, and that the indraft caused by this torrential rainfall determined the formation and growth of the cyclonic storm. If it developed in the manner indicated, as appears to be very probable, its origin would be similar to that of cyclonic storms in the Bay during the October Transition Period.

The previous remarks hence establish that it is very probable that the circumstances of the origin of this storm were as follows. The storm originated in a sea area which had been characterised by a moderate deficiency of pressure for some time previously, due to peculiarities in the set of the Bay monsoon current and the consequent distribution of rainfall. Temperature conditions were probably normal in the area and the chief feature was uniform temperature with very slight diurnal range. Winds were probably very light, but a humid current continued to blow towards it across the south of the Bay. A rise of pressure in Southern India checked the advance of the current to that area, and thus determined it more largely, if not chiefly, to this area. It thus became an area of local concentrated rainfall and of squally weather which developed into a cyclonic storm.

Cyclone resembled in important points False Point cyclone of September 1885.

The storm was apparently generated rapidly, and, if so, its velocity increased very quickly up to a maximum of about 20 miles per hour. In both these respects there are parallel storms of the Bay of Bengal. It is sufficient to quote one example, the account of which has been drawn up by an independent authority. The False Point cyclone of September 1885 was formed in a small area of torrential rain to the south-west of Diamond Island on the 22nd of September and advanced with rapidly-increasing velocity across the north of the Bay. It passed centrally over False Point, at which time it was advancing at an average rate of 15 miles per hour. It may also be noted that the

False Point cyclone more closely resembled the present cyclone in all its important features than any other storm of recent occurrence.

Rapidity of its growth.

The available information hence suggests that the storm under discussion developed very quickly, probably on the 29th and 30th, and that it began to move with rapidly-increasing velocity on the 30th and 31st, and that on the evening of the 31st, when approaching the Lower Siam coast, it was advancing with a velocity of nearly 20 miles per hour. In these respects it agrees with similar storms in the Bay of Bengal—storms which have originated in a small area of concentrated and torrential rainfall; and it hence probably originated under similar conditions in the Gulf of Siam, and, as already pointed out, the known antecedents in the Indian area are in favour of these suppositions.

The cyclone was a storm of low elevation.

The course of the storm in the Gulf of Siam directed it to the lowest part of the Malayan Peninsula, *viz.*, the Isthmus of Krah. The districts covered by the storm in Lower Siam are comparatively low and only broken by isolated hills of altitude not exceeding 2,000 feet. They hence presented hardly any obstacle to the storm, which crossed the Peninsula levelling and destroying trees and houses within the inner storm area. It also passed over the comparatively low ground of the Little Andaman Island (highest point, Mount Harriet, 1,300 feet) apparently unchanged in character. These hills were hence probably of low elevation relative to the chief seat of activity in the cyclonic whirl. On the other hand, the cyclone resembled, in the large barometric depression and intensity of the lower air circulation, the more intense storms of the October Transition Periods generated in the Bay area. It was rapidly broken up, when its course directed it across Bengal. It was hence almost certainly a cyclonic storm or cyclone of low elevation, the whole motion being restricted to less than the lower 10,000 or 15,000 feet of the atmosphere over the Bay, and probably considerably less.

Intensity of the storm.

The intensity of the storm may be estimated in two ways, *viz.*, by the maximum depression of the barometer in the inner storm area below the normal of the period, or by the steepest gradients.

The following give the lowest barometric readings observed in or near the calm central area on different dates:—

Intensity of the storm as gauged by the maximum barometric depression in the storm area from day to day.

	Date.	Position with regard to calm centre.	Corrected and reduced barometer to sea-level and constant gravity.	Variation from normal of day.
			″	″
Port Blair . .	2nd— 2 A.M.	9 miles from central area.	28·254	–1·55
	3 A.M.	5 miles from central area.	28·359	–1·43
Puri . . .	5th— 6 A.M.	25 miles from central area.	29·068	–0·77

	Date.	Position with regard to calm centre.	Corrected and reduced barometer to sea-level and constant gravity.	Variation from normal of day.
			"	"
False Point Light-house . . .	5th— 3-45 P.M.	2 miles in front of calm centre.	28·012	—1·83
False Point Port Office . . .	5th... 5 P.M.	Just outside the calm centre.	28·190	—1·66
Shortt's Island . .	5th— 8 P.M.	25 miles north from calm centre.	29·028	—0·86
Intermediate station.	6th— 2—0 A.M.	In calm centre.	28·670	—1·22
Lena	6th— 1-15 A.M.	In calm centre.	28·000?	—1·89
Lincolnshire . .	6th— 2-A.M.	5 to 10 miles from calm centre.	28·860	—1·03
Japan . . .	6th— 2-20 A.M.	20 to 30 miles from calm centre.	29·150	—0·78

The Port Blair observations do not give the pressure at the time the central calm was passing over it. They, however, indicate that pressure was almost certainly as low as 28·00 inches and probably lower. Allowing for the time it took the storm to travel from the observatory to the barque *Safir*, it is probable that the calm centre passed over Port Blair between 2-20 and 2-35 A.M. (assuming that the time was correctly kept on board the barque *Safir*). Interpolation in the Port Blair observations based on the character of the pressure changes of the storm when passing over False Point shows that the barometer probably read about 27·75 inches in the calm centre, and hence the probable maximum depression of the barometer was 2·1 inches at that stage.

No vessel was near enough to the centre on the 2nd, 3rd, and 4th to give data of the maximum depression on these days. The calm area passed centrically over False Point Light-house. The lowest observed pressure was 28·012 inches a little outside the calm area, and the depression of the barometer below the normal 1·83 inches. The corrected reading at 2-30 A.M. of the 6th of the mercurial barometer on board the Intermediate Station Light-vessel when the calm central area was passing over was 28·67 inches. This is confirmed by the reading of an aneroid barometer at the same time, which was 28·70 inches. This instrument, it may be noted, is of an unusually good make and has been found by the experience of several years to agree closely with the mercurial barometer on board the vessel (which is a marine K. P. barometer supplied by the India Meteorological office.) The reading of an aneroid barometer on board the ship *Lena* at about the same hour near the calm centre was 28·35 inches, but this is almost certainly wrong for reasons given in pages. 89 and 90. Hence assuming that the reading of the barometer of the F. L. V. *Canopus* was correct, pressure in the central calm had increased from 28·15 inches at 5 P.M. of the 5th to 28·67 inches at 2-30 A.M. of the 6th—an additional proof to those already given that the storm began to fill up during the night of the 5th.

A consideration of these facts, and of the observed pressure at distances of 10 to 30 miles from the calm central area, appears to establish the following inferences:—

(1) From the morning of the 2nd (and probably from the afternoon of the 31st October) up to midnight of the 5th or 2 A. M. of the 6th the minimum pressure in or just outside of the calm area was less than 28·1 inches, and was very probably slightly below 27·75 inches on the 1st and 2nd.

(2) The maximum depression in and near the calm central area hence undoubtedly ranged between 1·6 inches and 1·83 inches during this period, and was very probably slightly greater than 2·1 inches on the 1st and 2nd.

(3) It is hence on the whole probable that the maximum depression decreased slightly on the 4th or 5th, but the decrease, although it may have amounted to ·25 inch, was small compared with the total amount of the depression, and it is very doubtful whether it exceeded 15 per cent. of the amount of the maximum depression.

(4) It would hence appear that the maximum barometer depression, and therefore the pressure conditions of the calm central area, were remarkably uniform during the whole of this period from the 31st to the afternoon of the 5th, including an interval of nearly six days; thus indicating a remarkable persistence and steadiness of the conditions of the central calm area and inner storm area, or core of the storm. This appears for various reasons to be an important feature of the storm, if it be true.

Intensity of the storm as measured by the magnitude of the steepest gradients in the storm area.

The unit of gradient adopted by European meteorologists is ·01 inch per 15 geographical miles, equivalent to a fall of one millimetre in one geographical degree approximately. The mean pressure difference during the south-west monsoon period is barely ·3 inch over the Bay of Bengal between Lat. 7° N. and Lat. 22° N. This mean pressure difference over the Bay corresponds to a mean gradient of nearly half. The gradients of course vary in different parts of the Indian land and sea area during the south-west monsoon, but they probably rarely exceed 1 or 2, except in the neighbourhood of, or within any area affected by, a cyclonic storm of the rains. It may also be noted that gradients seldom exceed 5 to 10 in European cyclonic storms.

The following gives the steepest observed gradients in the Port Blair cyclone as determined by accurate observations taken at the two land observatories in its path :—

STATION.	Interval.			Difference of pressure.	Gradients.
	Hour.		Hour.	Inch.	
Port Blair	1	to	2	·900 fall	67½
False Point Light-house . .	14	to	14-30	·372 „	112
	14-30	to	15	·302 „	91
	17	to	17-30	·306 rise	92
	17-30	to	18	·310 „	93
False Point Port Office . .	15	to	15-30	·200 fall	60
	15-30	to	15-45	·100 „	60
	15-45	to	16	·180 „	108
	17	to	17-30	·110 rise	33
	17-30	to	18	·270 „	81

If it be assumed that the lowest pressure at Port Blair was 27·75 inches and that it occurred between 2-20 to 2-35 A.M., this would give a fall of pressure of half an inch in a distance of 7 to 12 miles. The former would correspond to a gradient of nearly 110, agreeing closely with the observed gradients at False Point. It should also be noted that these are mean gradients based on observations taken at half or quarter hourly intervals; and hence not the maximum gradients during any one of these intervals. It is almost certain that the steepest gradients exceeded 120.

The following conclusions respecting the steepest gradients in this cyclone are based on the previous data and the connected considerations :—

(1) The steepest horizontal gradients in the storm were in the front or advancing quadrant, and almost certainly exceeded 100, and probably slightly exceeded 110 during by far the greater part of the existence of the storm. These are the mean gradients based on observations taken at quarter or half-hour intervals, and it is possible that the steepest gradients may have been at least 25 per cent. greater, and may have exceeded 150.

(2) The steepest horizontal gradients observed in the western or retreating quadrant ranged between 80 and 100, and were about 20 per cent. smaller than the steepest gradients in the advancing quadrant.

(3) The maximum gradients in the inner storm area were almost certainly remarkably steady from the evening of the 1st and probably from the evening of the 31st until midnight of the 6th, and probably did not, under similar conditions of measurement, vary more than 10 per cent. during this interval.

(4) Hence the maximum gradients near the calm central area this storm as well as the maximum barometric depression w remarkably steady and uniform during a period of at least six days

The preceding data hence establish that the mean pressure or just in front of the central calm area from midnight of the 3 to midnight of the 5th averaged 28·00 inches, the maximum depressi averaged 1·9 inches, the maximum gradients in the advancing qu rant averaged 110, and in the retreating quadrant averaged 90. T variation in these elements during the whole period was almost c tainly less than 20 per cent., and probably not more than 10 to 15 cent.

Data of the filling up of the central depression.

In connection with this it is interesting to note the rate at wh the intensity of the storm, as measured by the maximum baromet depression, diminished whilst it was filling up.

The following table gives the chief data :—

STATION.	Date and hour.	Pressure reduced to seal level and constant gravity.	Variation of sure from t normal pres of place a date.
	2nd—		
Port Blair (in calm centre) . . .	1·25 A.M.	27·75 (?)	—2·054
	5th—		
False Point (centre)	3·45 P.M.	28·012	—1·83
	6th—		
F. L. V. *Canopus* (centre) . . .	2·30 A.M.	28·670	—1·17
Saugor Island (near centre) . . .	8 A.M.	29·670	—0·279
Calcutta	8 A.M.	29·722	—0·211
Dacca	4 P.M.	·689	—0·12
	7th—		
Silchar	8 A.M.	·844	—0·08
Silchar	4 P.M.	·821	+0·01

The data show in the first place that the depression was nearly great at False Point as it was four or five days before, when the sto was crossing Port Blair and the Malayan Peninsula. They also est lish that it began to fill up rapidly shortly after it advanced over Fa Point, and that it filled up very rapidly between 2 A.M. and 8 A.M. of 6th, during which interval the rate of increase of pressure per hour ·14 inch, or nearly a seventh of an inch. The total rise during period between 4 P.M. of the 5th and 8 A.M. of the 6th was 1·5 inc and the depression decreased from 1·83 inches to about ·35 inch dur the same period. Hence it is very probable that the calm cent area contracted rapidly in size during this period and filled up bef 8 A.M. of the 6th. This appears to be fully confirmed by the sh interval of calm experienced by the F. L. V. *Canopus*, *Foam*, other ships, which were involved in the calm centre at the Sa heads between 1 and 3 A.M. of the 6th. Thus the calm in the c of the *Canopus* is stated to have lasted 3 or 4 minutes, and in the case of the *Star* 10 or 15 minutes. The length of time is not stated in the case of the S. S. *Lincolnshire*, but was apparently short. It is of course possible that the calm area did not pass centrically over the *Canopus* or *Star*, but when it is remembered that these vessels, as they had broken away from their moorings, were almost certain to drift with the storm, it appears to be most probable that the calm central area was much smaller at 2 A.M. of the 6th than it was at 4 P.M. of the 5th, and hence that it was contracting in area at that time. There is no evidence forthcoming of the existence of a calm centre during the passage of the storm across South Bengal, and it is hence very probable, if not almost certain, that it completely filled up and disappeared before 8 A.M. of the 6th.

Magnitude of the storm.

The calm central area when passing centrically over Port Blair and the barque *Safir* was nearly 5 miles in width in an easterly and westerly direction or in the then direction of advance of the storm. It passed centrically over False Point Light-house on the afternoon of the 5th, and its diameter in the direction of advance of the storm was slightly greater than 5 miles. Considering the character and phenomena of the storm during the whole of its existence and the remarkable permanence of the chief features of the storm during the greater part of its existence, it is almost certain that there was a well-defined calm central area from the afternoon of the 31st up to 3 or 4 A.M. of the 6th, and that it formed one of the more conspicuous and important features of the storm. Its diameter in the direction of advance of the storm was practically the same in length on the 5th as on the 2nd, the only days for which there are data that enable it to be approximately measured. It is hence very probable that during the whole of the period from midnight of the 31st to that of the 5th the calm central area was practically unchanged in magnitude.

There are no data from which an estimate of the shape of the calm area of the storm at any stage can be directly inferred. It is, however, most probable that it was, like the inner storm area, oval or elliptical-shaped and that its greatest diameter was in the direction of the advance of the centre and approximately 5 miles in length.

The inner storm area or area of fierce and destructive winds (force 10 to 12) has been ascertained at several stages throughout the storm. It was probably about 30 miles in its longest diameter and 60 miles in the shortest direction when crossing the Malayan Peninsula (*vide* page 38). When advancing over the South Andaman Island it was between 70 and 80 miles in length by 50 to 60 miles in breadth (*vide* page 55). The inner storm area appears to have taken between 8 and 9 hours in passing over False Point Light-house. The rate of advance of the storm at that time was nearly 10 miles an hour. The diameter of the inner storm area (in the direction of advance) was hence at that time probably between 80 and 90 miles.

The whole of the data strongly support the inference that the inner storm area was practically unchanged in shape and extent from the evening of the 31st to that of the 5th. It was almost certainly elliptical-shaped throughout, its largest diameter averaging 80 miles and shortest diameter (probably) 60 miles. The direction of its longest diameter coincided approximately with the direction of advance of the storm centre throughout its whole existence.

It is much more difficult to estimate the extent of the outer storm area. It is, however, certain in the present case that when the storm entered the Andaman Sea it did not affect the weather and winds to any considerable extent at distances of 100 miles to the north and south. As it advanced over the Bay the area of strong winds and squally to stormy weather increased largely in extent. The extension occurred chiefly in the eastern and southern quadrants, where the indraught to the cyclonic storm intensified the south-west monsoon humid winds. For example, on the 5th, winds of force 8 (moderate gale) were experienced at distances of at least 300 to 350 miles from the centre in these quadrants.

Hence the important inference that the calm central area and the inner storm area were almost unchanged in extent, and in several other characteristic features from the 1st to the 5th, but that a very considerable extension occurred during this period in the outer storm area. The extension was greatest and most marked in the eastern and southern quadrants, the quadrants into which the humid winds that maintained the storm were chiefly drawn.

Calm centre.

The features of the calm centre of the cyclone, as far as they are indicated by the observations taken at False Point and Port Blair, have been fully described in the body of the report. The following gives a summary :—

(1) Pressure was lowest at some little distance in front of the calm area.

(2) Pressure was not quite uniform in the calm area, but increased slightly in proceeding along the diameter coinciding with the direction of advance and in the opposite direction.

(3) The air was practically, if not absolutely, calm within the calm area proper.

(4) The transition from the hurricane winds in front to the central calm was not sudden, but gradual; and similarly in the rear the transition from the calm to hurricane winds was not instantaneous, but gradual. This is fully established by the observations, taken at the False Point Light-house. The Port Office observations show that the same held good on the verge of the north-western half of the calm area.

(5) The observer at the False Point Light-house thus describes the appearance of the sky when the calm centre was passing over it. "The sky was covered with broken cloud, and there was a heavy bank to eastward."

(6) The mercury column did not pulsate in the calm area as it did outside of it in the area of hurricane winds and fierce gusts. The light-house keeper at False Point states—

> "I noticed that during the approach of the storm the pointer of the aneroid oscillated a good deal, jumping up and down fully one-tenth of an inch, and the same thing occurred when the storm was receding; but during the time the centre was passing it remained quite steady. At one time during the approach of the storm the pointer went as low as 28·08" with the oscillation. I have noticed a slight oscillation of two or three hundredths of an inch in other cyclones, but never to such anextent as in this one."

It is hence evident that these pulsations are dynamical and due to the rapid variations of the strength of the winds, and are not communicated to neighbouring masses of air as a statical increase of pressure would be, for if they were, it is evident that the pulsations would have been felt within the calm area. It maybe noted that the barometer at the False Point Light-house observations is kept in one of the lower rooms of the light-house, and that the doors and windows were closed.

The following features of the calm area and inner storm area are of importance in connection with any theory for the formation advance, etc., of cyclones of the character of the Port Blair cyclone of 1891:—

(1) The transition from the calm central area to the inner storm area as measured by the change in the strength, etc., of the winds was very rapid, but was by no means instantaneous.

(2) The transition from the inner storm area to the outer storm area (as measured by change in strength of the winds and the amount and character of the destruction) was very rapid, but was not instantaneous, as is clearly shown in Mr. Portman's account of the destruction due to the storm.

These features, it may be noted, are in full accordance with the observed data of the most severe cyclones that have been previously observed in Bengal and Orissa, and are important because they establish fully the existence of these three areas (*viz.*, the calm area, the inner storm area, and the outer storm area), as well defined portions of the storm area, in each of which the barometric changes and features are in exact accordance with the character of the winds observed.

Temperature conditions preceding and accompanying the storm.

There is no available information concerning the temperature conditions of the Gulf of Siam immediately before and during the formation of the storm.

The mean temperature data of the month of October 1891 given in page 14 show that there were no large variations from the normal conditions in India or Burma. The mean temperature of the month was normal in Lower Burma and was in slight defect over the greater part of India.

Similarly during the last week of October the temperature conditions of Lower Burma and the Bay Islands presented no large or important variations from the normal. Weather had been showery and of the usual character from the 1st to the 23rd or 24th October. Fine dry weather with clear or lightly clouded skies set in, and practically no rain fell during the remainder of the month. In consequence of this change the day temperature rose above the normal and the night temperature fell below it, but the variations of the mean temperature of the day were small throughout the whole period.

The following gives data for seven stations :—

Station.	CHANGE OF MAXIMUM TEMPERATURE DURING 24 HOURS ENDING AT 8 A. M. OF THE				
	27th.	28th.	29th.	30th.	31st.
	°	°	°	°	°
Mergui	—0·7	+0·2	+0·5	—0·7	+0·1
Tavoy	—1·3	+0·3	—0·5	0	+1·5
Port Blair	—3·9	+3·6	+0·2	+0 4	+0·2
Moulmein	+1·7	—3·0?	0	+0·3	+1 7
Diamond Island	—0·9	+1·0	0	+0·7	+1·7
Akyab	—0·5	+1·3	—0·3	+0·3	+0·2

	VARIATION OF MEAN TEMPERATURE FROM THE NORMAL OF THE 24 HOURS ENDING AT 8 A. M. OF THE				
	27th.	28th.	29th.	30th.	31st.
	°	°	°	°	°
Mergui	—1·6	—1·9	—1·4	—1·7	—1·1
Tavoy	+0·7	—0·8	—0·5	—0·4	+0·9
Port Blair	—2·2	+0·9	+0·9	+1·8	+2·0
Moulmein	+3·0	+0·4	+0·5	+0·9	+2·9
Bassein	—1·6	—0·4	—0·9	—0·9	+.0·6
Diamond Island	—2·6	—1·6	—1·6	—1·0	+0·9
Akyab	—0·6	+0·2	0	—0·3	+0·1

The minimum thermometers at Diamond Island and Moulmein were not very satisfactory at this time, the former reading too low and the latter too high, and hence the variation of the mean temperature of the day for these two stations (based in part on the minimum observations) cannot be accepted as quite correct. The erroneous readings exaggerated the deficient temperature at Diamond Island and the increased temperature at Moulmein.

It will be noted that these temperature data give no indication of any large variation of the temperature conditions from the normal in the Andaman Sea, Tenasserim or Lower Burma immediately antecedent to the formation of the storm in the Gulf of Siam. The changes of temperature from day to day were small, and the variations of the mean temperature from the normal were relatively small but generally negative, showing that on the whole temperature was slightly in defect.

Hence these temperature observations suggest that it was on the whole probable there were no marked variations of the temperature conditions from the normal in the Malay Peninsula or the Gulf of Siam, which would account for the origin of the storm according to the theory of Ferrel.

The temperature conditions accompanying the storm during its passage across the Bay of Bengal cannot be ascertained from the data extracted from the logs of ships. The temperature observations at Port Blair, False Point, Saugor Island and Chittagong, all situated on the sea coast of the Bay and included within the storm area at different periods of its advance, indicate the larger temperature changes accompanying the progress of the storm.

Station.	Date.	Mean temperature of 24 hours preceding 8 A.M. of date.	Variation from normal.	Daily range.	Normal mean daily range.	Weather.
		°	°	°	°	
Port Blair .	1st .	83.8	+1.5	11.3	9.6	Cloudy.
	2nd .	74.4	—8.1	8.8	10.4	Cyclonic rain.
	3rd .	78.0	—4.0	4.5	9.7	Squally.
	4th .	78.5	—3.2	5.1	9.6	Ditto.
	5th .	81.1	—1.1	11.2	9.3	Monsoonish.
	6th .	80.7	—1.3	9.2	9.9	Cloudy.
	7th .	80.7	—1.4	8.7	10.3	Ditto.
Saugor Island.	1st .	76.8	—0.7	18.8	12.2	Fine clear.
	2nd .	77.6	+0.3	17.3	11.8	Dust haze.
	3rd .	77.6	+0.7	17.3	11.6	Fine with passing clouds.
	4th .	78.1	+1.6	18.3	12.1	Threatening.
	5th .	77.6	+1.6	3.2	12.4	Ditto.
	6th .	75.9	+0.2	8.7	12.6	Severe gale of wind.
	7th .	75.6	+0.2	11.2	12.7	Cloudy.
False Point .	1st .	77.2	—1.3	18.4	11.6	Fine with passing clouds.
	2nd .	77.3	—1.1	15.3	11.1	Fine clear.
	3rd .	78.0	+0.2	14.8	11.4	Fine with passing clouds.
	4t	79.7	+2.4	9.2	12.1	Dark, gloomy.
	5th .	79.3	+2.5	2.2	12.8	Gale of wind.
	6th .	72.7	—3.5	11.4	13.8	Heavy rain during previous 24 hours.
	7th .	76.0	0	8.8	14.2	Dark, gloomy.
Chittagong .	1st .	76.9	—1.1	22.6	14.7	Fine, clear.
	2nd .	79.2	+1.4	23.1	14.2	Ditto.
	3rd .	77.9	+0.5	21.6	13.9	Dull.
	4th .	78.9	+1.7	14.6	13.9	Cloudy.
	5th .	76.4	—0.7	10.3	14.1	Dull.
	6th .	76.7	—0.2	10.9	14.3	Overcast.
	7th .	76.4	0	9.6	14.6	Galefowipn·

The mean temperature of the 1st and 2nd was below the normal in Bengal in consequence of the large deficiency in the night temperature. The day temperature was slightly in excess, and hence the daily range of temperature was considerably (6° to 8°) above the normal. With the passage of the storm into the Bay of Bengal from the Andaman Sea cloud extended northwards and fine weather with increasing cloud prevailed for some days. This at first produced little effect, but when the skies became thickly clouded the day temperature was reduced and the night temperature raised largely above the normal. The mean temperature of the day was hence raised slightly above the normal and the daily range of temperature largely decreased. In the districts in which rain fell in moderate to large amounts a considerable reduction of temperature due to this cause occurred.

The preceding data hence show that in this storm, as in cyclonic storms generally in the Bay, the mean daily temperature remained almost unchanged, and the small changes which occurred were almost solely due to the heavy rainfall. There were on the other hand large changes in the diurnal range of temperature, chiefly due to the action of cloud in diminishing solar and terrestrial radiation.

Hence the temperature changes in the sea area of the Bay and at the coast stations accompanying this cyclone were small as compared with the corresponding changes in storms in temperate regions. They were not due to any marked thermal differences between the winds of indraught in different quadrants, but were solely the effect of cloud and of rainfall in tempotarily modifying the temperature conditions.

Rainfall.

As the storm passed chiefly over a sea area, the data for determining the character and distribution of rainfall accompanying the storm are limited. The rainfall in the storm area whilst it was crossing the Bay of Bengal was of the usual torrential character. Captain Beahan, of the F. L. V. *Canopus* at the Intermediate station writes that the rain was heavier than he had experienced in any previous storm at the head of the Bay. The commander of the F. L. V. *Foam* states that the storm began at his station with a heavy squall and torrents of rain. The S. S. *Saint Regulus* had very heavy rain, the S. S. *Japan* continual heavy rain, and the S. S. *Lincolnshire* terrific rain squalls.

The rainfall data of the period of the storm in the land area included within the storm are given in full in " The Rainfall of India in 1891." These areas are Assam and South Bengal.

When the storm crossed the Malay Peninsula it was of small extent and the rainfall did not extend much beyond the storm area proper. Mergui received light to moderate showers on the 1st and 2nd, but Tavoy, Moulmein and Rangoon had, on the contrary, fine dry weather. As the storm advanced over the Bay and the outer storm area extended outwards, especially in the eastern and southern quadrants, the rainfall area increased very considerably in extent, and on the 4th and 5th rain squalls were experienced at distances of 300 to 500 miles from the centre.

The storm was in its most intense stage when passing along the Orissa coast on the afternoon of the 5th. The following gives the available rainfall data of Orissa for the period of the storm :—

DISTRICT.	Station.	RAINFALL OF 24 HOURS PRECEDING 8 A.M. OF THE			TOTAL RAIN-FALL.
		4th.	5th.	6th.	
		Inches.	Inches.	Inches.	Inches.
	Puri	0·50	13·61	1·80	15·91
	Khurda	0·06	2·56	1·12	3·74
PURI	Banpur	1·40	0·10	...	1·50
	False Point	0·20	3·84	7·02	11·06
	Gop	0·70	5·00	14·00	19·70
	Satpura	0·25	3·35	0·13	3·73
	Pipli	0·40	3·95	2·63	6·98
	Jagatsingpur	1·37	4·80	6·30	12·47
	Banki	0·06	1·01	0·10	1·17
CUTTACK	Cuttack	0·09	2·63	2·15	4·87
	Kendrapara	0·21	6·21	9·50	15·92
	Jajpur	...	1·10	2·11	3·21
	Dharmsala	2·04	3·25	...	5·29
	Salipur	5·70	2·50	...	8·20
	Chandbali	0·20	2·26	7·92	10·38
BALASORE	Bhadrak	0·16	1·35	3·79	5·30
	Sora	0·12	1·51	2·30	3·93
	Balasore	0·10	0·75	1·62	2·47
	Jellasore	...	...	0·82	0·82
	Buripoda	...	0·35	...	0·35

The preceding statement shows fully the excessive amount of the rainfall at Puri, Gop, False Point, Kendrapara, Jagatsingpur and Chandbali, the stations nearest to the track of the centre.

It is not possible to deduce with certainty from this statement the character of the rainfall in different quadrants of the cyclone area. The evidence is, however, strongly in favour of the suppo that the rainfall was heaviest in the advancing quadrant. Pu striking example. The centre was 10 miles to the east of Pur A.M. of the 5th. During the previous 24 hours 13·61 inches of rai fallen, and during the next 24 hours only 1·80 inches were rece Equally strong evidence is furnished by the rainfall at False where 11·06 inches fell during the storm. The following give time distribution of this rainfall as recorded at the Light-house

Day.	Hour.	Rainfall during the interval since the last previous measurement.	Rate of f hour dur terval.
		Inches.	Inch
4th	8 A. M.	0·20	...
	10 A. M.	0·52	0·26
	4 P. M.	0·41	0·07
5th	8 A. M.	2·91	0·18
	10 A. M.	0·94	0·47
	2 P. M.	1·60	0·40
	4 P. M.	1·90	0·95
	5 P. M.	0·26	0·26
	8 P. M.	1·42	0·47
	11 P. M.	0.50	0·17
6th	2 A. M.	0·15	0·05
	8 A. M.	0·25	0·04

Total rainfall during the storm 11·06 inches.

The rainfall at False Point was heaviest and most intense bet 2 P.M. and 4 P.M., and hence in the advancing quadrant. inference is, it may be noted, in harmony with the known respecting the rainfall experienced by the F. L. V. *Canopus Foam.*

The storm was breaking up as it passed through Bengal, and t the rainfall data of that province show the distribution of the prec tion when the storm was disintegrating and not when it was ir vigour. No rain fell in Bihar and the greater part of North Be

Light showers fell in the Assam Valley. The following gives data of the rainfall in the remainder of Bengal and in Cachar:—

METEOROLOGICAL DIVISION.	District.	Number of stations.	AVERAGE ACTUAL RAINFALL OF 24 HOURS PRECEDING 8 A.M., OF			TOTAL RAINFALL DURING STORM.
			5th.	6th.	7th.	
			Inches.	Inches.	Inches.	Inches.
SOUTH-WEST BENGAL	Midnapur	7	0·04	1·10	*Nil*	1·14
	24-Parganas	7	0·01	0·53	0·17	0·71
	Howrah	3	0·12	0·21	0·02	0·35
	Hooghly	3	*Nil*	0·28	0·01	0·29
	Burdwan	5	0·07	0·36	0·06	0·49
	Birbhum	5	0·34	0·97	0·01	1·32
	Nadia	5	0·01	0·51	0·01	0·53
	Khulna	5	0·03	0·69	1·76	2·48
	Jessore	5	0·01	0·25	0·55	0·81
	Murshidabad	8	0’11	0·88	0·07	1·06
EAST BENGAL	Chittagong	4	0·05	0 27	0·61	0·93
	Backergunge	6	*Nil*	0·43	0·81	1·24
	Noakhali	4	*Nil*	0·09	0·60	0·69
	Furridpur	3	0·10	0·10	1·64	1·84
	Dacca	5	0·03	0·10	1’68	1·81
	Tippera	8	0·01	0·26	2·73	3·00
	Mymensingh	8	0·15	1·09	0·33	1·57
NORTH BENGAL	Pabna	2	0·03	0·79	0·15	0’97
	Bogra	4	0·19	1·60	0·31	2·10
	Rajshahye	5	0·15	0·83	0·17	1·15
	Malda	4	0·06	0·28	*Nil*	0·34
ASSAM, SURMA	Cachar	9	0·15	0·81	0·52	1·48
	Sylhet	11	0·04	0·40	1·30	1·74

The centre crossed the coast of the 24-Parganas about 8 A.M. of the 6th and advanced through the districts of Khulna, Backerganj, and Tippera, and passed into Cachar on the morning of the 7th. Taking this into consideration, an examination of the preceding data shows that the rainfall was much heavier in the advancing than in the retreating quadrant, and that it was heaviest in front and probably a little to the north or left of the centre in the advancing current.

The rainfall data of the storm hence support the following inferences:—

(1) The rainfall accompanying the storm was excessive and torrential in character whilst it was in full vigour.

(2) The rainfall diminished rapidly on the 6th, whilst the storm was filling up, and practically ceased before the residual depression had disappeared.

(3) The rainfall was heaviest in the advancing quadrant, not only whilst the storm was fully developed, but also whilst it was filling up. The contrast between the rainfall before and after the advance of the centre was in the cases for which we have exact data (*e.g.*, Pooree and False Point) very noteworthy.

Strength of the winds in the inner storm area.

The winds were exceptionally violent in this cyclone. The anemometers and wind vanes were blown away at four observatories, *viz.*, Port Blair, False Point, Puri, and Shortt's Island. The centre passed over the first two. Puri was about 15 miles from the centre when it was nearest to it and Shortt's Island 25 miles.

The following gives the greatest wind velocity as recorded by the anemometers at the stations in and near the calm central area during its progress:—

STATIONS.	Air movement in miles per hour.
Port Blair	111·5 miles, 4 A.M. of the 2nd.
Gopalpur	42 miles at 11 P.M. of the 4th.
Puri	96 " " 9 " " "
Shortt's Island	64 " " 4 " " 5th.
Saugor "	77 " " 5 A.M. " 6th.

The velocity was determined in the case of Puri, Shortt's Island and Saugor Island by means of observations of the anemometer taken at intervals of three minutes, and hence represents very approximately the velocity at these hours.

It is hence very probable, if not almost certain, that in the strongest blasts the air velocity was certainly not less than 150 miles per hour and may have been as much as 200, corresponding according to the usual formula to a horizontal pressure of about 90 lbs. per square foot on an obstacle. Assuming the known maximum gradients in this storm and using Ferrel's formula giving the relation between the baric gradients and air velocity in cyclones, we should get a velocity of about 130 miles per hour.

The destruction of life and property seems to have been greatest when crossing the Malayan Peninsula. The storm was nearly as destructive when advancing over the South Andaman Island.

The destruction was comparatively small in the Orissa Coast districts, but this was in part at least due to the fact that it was never included in the quadrant of the strongest winds.

Mr. Carroll states in a recent letter a remarkable result of the fierce sea and heavy ground swell due to the storm. He says that after the storm coral reefs were left exposed in several parts of the harbour where formerly they were not visible, and further states in a second letter on the subject—

"Coral reefs have not simply been thrown up, but the configuration of the place has been changed. Where lighters of several tons weight could easily approach the shore before at high tide has now changed to shallows of many yards out. In Ross Island a jetty constructed a short time ago to land Commissariat firewood has had to be abandoned for that purpose."

Electric phenomena of storm.

The electric phenomena were, so far as can be judged from the whole of the data, slight and of little importance until the storm approached the Orissa and Bengal coasts. At this stage the amount of electric action was one of the more striking features of the storm. Thus Captain Beahan writes—

> "In all my experience at the Sandheads during the last 16 years I have never seen anything like the heavy rain, thunder and lightning . . . that we experienced in the storm."

Mr. Elson speaks of the white vivid flashes of lightning.

The remarks of Captain Beahan and Mr. Elson on this point are in accordance with the general experience of cyclones that approach the north-west angle of the Bay. Thunderstorms and vivid thunder and lightning most frequently occur in India during hot weather storms and at the commencement and end of the monsoon rains, and occasionally at the termination of the periods known as breaks in the rains. Their law of occurrence appears to indicate that the production of electricity is not due solely to condensation of aqueous vapour under ordinary circumstances or to friction of a humid mass of air with a land or water surface, but that the rapid admixture or interaction of two air currents of very different hygrometric conditions is an essential condition for the rapid production of electricity. In the case of the present cyclone, when it was crossing the Andaman Sea and the centre of the Bay, the hygrometric conditions of the currents of indraught did not differ to any large extent, and hence there was little or no severe lightning and thunder at that stage. On the other hand, when crossing the north-west angle of the Bay, the indraught in the north-western quadrant introduced dry land winds of indraught, and the combination of these with the humid currents of influx from the south, gave rise to or facilitated the production of electricity rapidly and on the large scale.

Subsidiary whirls in storm area.

A noteworthy feature of this storm was the existence of small subsidiary whirls as part of the large general disturbance. There is some evidence of the existence for a short time of certainly two—and perhaps of three—subsidiary whirls in this storm. They were observed in the following cases:—

(1) By the S.S. *Arratoon Apcar* on the 3rd, 300 miles to the south-east of the storm centre.

(2) At Gopalpur on the 5th.

(3) In the Hooghly near Saugor Island on the 5th.

The first is the most remarkable. The following gives the observations recorded in the log of the S.S. *Arratoon Apcar* on the 3rd:—

Hour.	Distance and bearing of vessel from centre.	Barometer, corrected.	Wind.		Weather remarks.
			Direction.	Force.	
		Inches.			
4 A.M.	385 miles N.N.E.	30·008	S.E.	5	Fresh breeze and fast rising sea, overcast and very hard squalls at times.
8 "	355 miles N.E. by N.	29·958	E.	6	Strong breeze and squally with rain and strong head sea.
Noon	340 miles N.E.	·918	N.E.	8	Fresh gale with hard squalls with heavy rain, thick sea.
4 P.M.	345 miles N.E. by E.	30·068	N.E.	8	P.M. Fresh gales with heavy squalls and dangerous cross sea running. 1-30 P.M. Wind fell away to a calm for 3 minutes, after which the wind shifted about from north-east to west and finally settled back to north-east, and the gale resuming its force.
8 "	355 miles E.N.E.	·168	N.E.	9	Hard gale with squalls of hurricane force accompanied with heavy rain, thunder and lightning.
Midnight	374 miles E.N.E.	·068	E.	9	Hard gale continuing, the squalls coming as before in terrible force with rain, thunder and lightning.

Assuming the observations to be correct, and allowing for the ordinary or diurnal oscillation of the barometer, pressure fell ·15″ between 4 A.M. and noon and increased ·25″ between noon and 4 P.M. These changes cannot be explained by a movement of approach to or withdrawal from the centre in the storm area. It was clearly due to some additional disturbance. The character of this disturbance is shewn by the fact that the *Arratoon Apcar* had for a short time at noon calms and light winds and that the wind which was north-east before the calm shifted to west as she passed out of the calm. The wind at 4 P.M. returned to its previous abnormal direction with respect to the distant cyclone centre, *viz.*, north-east, although the vessel was then nearly 350 miles to the north-east. She had a hard gale during the remainder of the day with squalls of hurricane force.

The only satisfactory explanation of the preceding weather and wind changes is that the *Arratoon Apcar* passed through a small whirl with an inner area of light and variable winds or calms. It might have been due to a succession of two squalls with an interval of feeble winds, but the barometric data and the shift of wind direction from north-east to west appear to be opposed to this explanation.

The only evidence in the case of Gopalpur is the statement of the observer that the calm centre passed over that station. This was undoubtedly not the case, and hence it is on the whole most probable that the calm at that station was merely a period of light winds between two severe squalls. So far as I have been able to ascertain, these calms between prolonged gusts or squalls occur most frequently in the western quadrants of cyclonic storms in the Bay.

The last instance is that described by Mr. Elson in the following words:—

> "A somewhat remarkable and sudden shift of wind took place at 7 P. M. The wind, which had been about north-east, all at once blew in a vicious south-east squall with heavy rain and lightning, and after about 15 or 20 minutes it suddenly fell calm for about two hours; it then freshened and blew in hard gusts from north-north-east, while vivid flashes of lightning lit up the heavy pall overhead. The barometer fell two-tenths during these hard puffs. These backings and veerings of the wind certainly pointed to eddies in the storm system which have not been made clearly evident by any laws of storms yet brought forward. Probably they indicate a sort of double or twin whirl."

In this case, as in that of the S. S. *Arratoon Apcar*, there were observed—

(1) a sudden shift of wind from south-east to north-north-east with an intervening period of calms;

(2) a fall of the barometer of about two-tenths of an inch.

Mr. Elson has observed the phenomena of cyclonic storms for many years, and it is hence certain from his description that this was more than a period of light winds between two severe squalls. If it was a subsidiary whirl it was stationary or moving exceedingly slowly, otherwise it is very unlikely the calm area or area of light variable winds in the case of a small whirl would require two hours to pass over a vessel at anchor.

Hence the simplest and most probable explanation of the phenomena described above, and which were observed by two independent competent observers, is that there were within the large disturbance small subsidiary whirls, and that one of these whirls passed over the S. S. *Arratoon Apcar* and another over the pilot vessel.

Subsidiary whirls in large cyclonic storms have, so far as I can ascertain, been observed in a few cases. One of the most noteworthy occurred in the Samoan hurricane of March 1889. The following extract from a report on that hurricane by the Marine Meteorologist, Hydrographic Office, United States, Navy Department, describes it.

" It will be noted from the report of H. M. S. *Calliope* that that vessel, when she steamed out of Apia Harbour on the 16th into the northerly gale, experienced a gradual but steady rise of the barometer, as was naturally to be expected, but that on the forenoon of the 17th there was a decided fall (about ·30"), followed by a still more rapid rise (about ·50"). No such fall of the barometer is recorded in the reports from the vessels at Apia, nor do the shifts of wind help us much in accounting for it. The only hypothesis by which it can be even partially explained is that a secondary, or storm of small size but considerable severity, passed close to the *Calliope* and between her and the islands to the southward, affecting her barometer but not the others. There is, of course, nothing very improbable about this (although one would expect the shifts of wind to have been more marked), and the formation of this secondary moving along a track about south-east by east may be assumed to explain the recurve to the southward and south-westward on the 18th and 19th of the Samoan hurricane itself, and its movement towards the East Cape of New Zealand (if it did move that way)."

Recurvature of storm.

The Port Blair cyclone during the first three or four days of its existence travelled in the ordinary direction of storms passing across the centre of the Bay in the month of November, *viz.*, west-north-west. When it had advanced as far as the centre of the Bay, it began to recurve to north. As it approached the west coast of the Bay it recurved more or less steadily on the 3rd, 4th and 5th, and the total recurvature of the storm was larger than in any storm in the Bay on record. Its track was N. 69° W. when it entered the Andaman Sea, and N. 55° E. when it passed into Bengal. The total recurvature during its passage across the Andaman Sea and Bay of Bengal was hence 124°. This occurred, as already stated, on the 3rd, 4th and 5th.

As invariably happens when a storm recurves in the Bay, the rate of advance decreased very considerably and varied to some extent with the amount of recurvature. The velocity of the storm centre, which averaged approximately 20 miles on the 31st, 1st and 2nd, decreased to 9 miles per hour on the 3rd and 4th, and increased slightly on the 5th and 6th to an average of 12 miles for the 24 hours preceding 8 A.M. of the 7th.

That recurvature should cause a decrease in the rate of advance of the storm is in accordance with ordinary mechanical principles. The general tendency of cyclonic storms in the Bay of Bengal is to advance in approximately straight tracks over the sea area. If they recurve, it is due to some obstruction or obstructive action, the conditions being such as to enable the storm to change its path without its rotatory motion being broken up. The higher portions of the East Ghâts in Ganjam and Vizagapatam frequently act as a barrier to storms advancing from the Bay. They form in these districts a mountain mass of considerable width, the higher elevations of which attain to heights of 5,000 and 6,000 feet. When a storm is advancing obliquely towards them, they cut off to some extent the indraught in the western quadrant. The indraught of the humid current in the eastern quadrant is practically maintained intact. In such cases (*i. e.*, when storms are advancing more or less obliquely to this part of the East Ghâts) they are usually deflected to the north and the centres recurve to an extent depending upon conditions of the storm itself or upon special or abnormal meteorological conditions obtaining at the time.

The following table gives data showing the amount of recurvature from the 2nd to the 6th and the velocity:—

Date.	Hour.	Direction.	Change in previous 24 hours.	Velocity.	Change in previous 24 hours.
				Miles.	Miles.
2nd . .	8 A.M.	N. 70° W.	—	450	—
3rd . .	"	N. 62° W.	8°	280	—170
4th . .	"	N. 42° W.	20°	220	—60
5th . .	"	N. 7° E.	49°	250	+30
6th . .	"	N. 43° E.	36°	230	—20

Breaking up of the storm.

The storm, as has been pointed out, was nearly as intense when passing over False Point at 4 P.M. of the 5th as when passing over Port Blair. It began to fill up during the night of the 5th. Pressure in the central area increased about six-tenths of an inch between 4 P.M. of the 5th and 2 A.M. of the 6th, at which hour it was crossing the Sandheads and was still a well-defined cyclone with a central calm and an inner storm area of hurricane winds. It filled up very rapidly during the next six hours. Pressure increased at the centre the rate of about ·115″ per hour. The storm at 8 A.M. was of mo ate intensity, and it is very probable that the calm central area filled up. The storm continued to fill up during the day and wa little importance at 4 P.M., although a small residual depression tinued to drift towards the north-east during the next 18 hours.

The causes of this rapid break-up of the storm during the nigh the 5th and morning of the 6th can only be surmised. There no large or general change in the meteorological conditions of I outside the storm area which would account for it. The pres changes outside the area affected by the storm were small and so what irregular, and the winds in the south of the Bay, as indicated the data for Colombo, Camorta and Port Blair, show no large cha either of direction or force. The causes must hence be sought in storm area itself and in the relation of the storm to the condition the area over which it was passing.

The storm recurved very rapidly on the 5th, and was, on evening of the 5th, moving across the Head of the Bay in an e north-east direction. The humid winds of indraught hence be to be subject to the obstructive action of the Arakan and Chittag Hills on the evening of the 5th, and this obstructive action increa during the night with the continued approach of the storm area wards these hills. There was moderately heavy rain in the Ara hill districts and light to moderate rain in the Chittagong Hill distr —facts which to some extent support the supposition.

As the cyclone was a storm of comparatively low elevation, resistance offered by the land to the winds of indraught in the low portion of the storm may have had some influence, but this does appear to be sufficient for the unusually rapid filling up of the sto whilst the centre was crossing the north-west angle of the Bay before it reached the coast of the Sunderbuns.

The immediate cause appears to have been the rapid diminut in the rainfall over the storm area during this period. This may h been due to the fact that the aqueous vapour supplies in the B was almost exhausted by the enormous drain on them during the p vious four days. This supposition cannot be tested. The follow assigns another and apparently adequate cause. It has been point out that the outer storm area received a considerable extension the 4th, and hence that the southerly humid winds of indraught ente the storm area at a greater distance from the central area on the and 5th than on the previous days. When the storm recurved to east-north-east on the 5th, these humid winds not only entered and affected the storm area at much greater distances than hitherto from the centre, but were directed more and more largely towards the Arakan and Chittagong Hills. This tended to diminish the rainfall immediately in front of the cyclone. This proceeded in an accelerating rate with the continued advance of the storm across Central Bengal towards Silchar. The breaking-up of the storm would hence appear to be due to the combinations of actions resulting from the extension of the storm area on the 4th and 5th, the recurvature of the storm and its advance across Central and East Bengal in a direction nearly at right angles to the Arakan and Chittagong Hills, and perhaps to the exhaustion of the humid currents. This storm in its more important features—more especially its intensity, extent and recurvature—resembled the Backergunj cyclone of October 1876. That storm crossed the coast at the mouth of the Megna, and was completely broken up within six hours of crossing the coast. The present storm, which crossed the coast 150 miles further to the west but advanced to the same districts of Assam, was upwards of 24 hours in breaking up. These facts apparently point to the existence of similar disintegrating actions of feebler intensity in the case of the present storm.

Chief features of the air movement in the cyclone.

The preceding discussion has established that in this, as in many cyclonic storms in the Bay of Bengal, the rainfall, although it occurred more or less vigorously over the whole storm area, was most excessive in front. Hence the seat of the most active condensation, and therefore of the most rapid ascensional motion, was in the advancing quadrant, at some distance in front of the calm central area. This inference from the distribution of the rainfall, it may be stated, is confirmed by the cloud movements as observed in these storms and by the differences in the strength of the winds or horizontal air movement at the same or corresponding distances from the centre in different quadrants. Hence in these storms, more especially when they are approaching the north-west or north coast of the Bay, there are very marked differences between the air movement in the different quadrants.

The strongest winds in the cyclonic storms of the Bay are invariably the intensified humid winds of indraught from the south or south-west. These winds usually enter the storm area in the south-eastern or eastern quadrant and are subject to an increasing horizontal acceleration and to an increasing upward movement in their course round and towards the centre. In the case of the storms with

a calm central area, these humid winds do not pass into the
centre and rise up as in a funnel, but are carried round and up,
thence pass out of the storm circulation. Hence it follows that
strongest winds (or most violent horizontal motion) should be obse
at some angular distance round, and that the most rapid ascensi
will occur still further round. In the remaining quadrants the indra
will be partly due to descending masses of air and partly to loca
draught from areas to the west or north. The descending mass
air, more especially when the storms are approaching the north-
coast of the Bay, give rise to similar actions to those which occ
nor' westers in the months of April and May in Bengal, as, for exam
violent electric action, and very heavy squalls of wind and
These differences in the character of the air movement in diffe
quadrants form one of the more important objections to the assu
tion that the motion of the air in a cyclone may be considere
compounded of a rotatory motion and of a movement of translat
The most important feature of the movement is the entrance
humid current into the storm area in one quadrant and its rapid up
movement and passage (in part at least) out of the storm are
another quadrant, *i.e.*, the advancing quadrant. An examination
the more recent storms in the Bay of Bengal indicates that am
considerable diversity in certain features they all agree in the
portant features described in the preceding paragraphs. The
Blair cyclone appears to have been a typical example in respec
these essential features. For example, when crossing the S
Andaman Island, the humid southerly winds entered the storm ar
the eastern quadrant, and the strongest winds were experience
the northern quadrant. A reference to the Chart Plate XVI (b
on an accurate survey of the destruction due to the cyclone) will
at once that the belt of destructive winds to the north of the track o
storm was much wider than that to the south. Ascensional move
was at that stage most active in the western quadrant as appea
be the usual, if not the invariable, rule in the case of storms cros
the Bay in a westward direction in the October transition period

The preceding remarks have established that aqueous va
condensation, rainfall, and hence ascensional motion, were
vigorous in the advancing quadrant at some distance in front o
calm central area. Assuming these features as conditions of the
vancing quadrant, the following consequences would appear to fo
from theoretical considerations:—

1st.—The increased uptake in the advancing quadrant would
rise to a local decrease of pressure due to that updra

and hence pressure would be lowest, not in the calm central area, but at some distance in front determined by the special conditions of the storm.

2nd.—This local decrease of pressure due to the upward movement would apparently affect the gradients. The steepest gradients in consequence of this action would be shewn in the advancing quadrant at some distance in front of the centre (and also of the area of greatest uptake in front of the centre).

3rd.—As a further consequence of this displacement of the seat of lowest pressure from the calm central area to a position in the advancing quadrant at some distance in front, the isobars should assume an oval form, the largest diameter being approximately in the direction of the greatest ascensional movement in the storm area and of the advance of the storm centre.

The valuable series of observations taken at the False Point Light-house during the storm, were fully in accordance with these theoretical conclusions; as they shew that—

1st.—the lowest barometer was observed at 3-45 P.M. when the calm centre area was about 2 miles to the south-west and approaching it;

2nd.—the steepest gradients were recorded between 2 P.M. and 3 P.M., or at some distance in front of the calm central area and the position of lowest barometer;

3rd.—the isobars of the storm area proper were oval curves, the largest diameter lying approximately in the direction of the track of the centre at that time.

It may be noted that the calm centre was upwards of 40 minutes in passing over the False Point Light-house, thus affording ample opportunity for recording the chief features exactly and carefully, and hence these observations are entitled to special weight.

Character of motion or apparent advance of the calm central area.

The history of the present storm shews that it had a well-defined calm central area during at least five days of its existence, *viz.*, from the early morning of the 1st to the morning of the 6th, and that it was, so far as can be inferred from the observations taken at two periods or stages of the storm, *viz.*, at Port Blair and at False Point, of almost constant magnitude during the greater part, if not the whole, of that period of five days. The mass of air in this calm central area was, unlike that of the rest of the storm area, practically, if not absolutely, at rest. The False Point observations establish that pressure was about a tenth of an inch lower just in front of this calm area than it was immediately in the rear. These facts would appear to suggest that the mass of air in the calm central area might be considered as a solid unchanging mass pushed forward by the excess of pressure in the rear. But further consideration will shew that this explanation cannot be accepted.

If the mass of air in the central calm area had been pressed forward as a solid column, its rate of advance would be that already given as the velocity of the centre, which varied between 20 and 10 miles as it marched from Port Blair to False Point. But a mass of air moving with a horizontal velocity of 20 miles (equivalent to 3·5 Beaufort scale, or a moderate breeze) or even 10 miles (equivalent to 1·5 Beaufort scale, or a light breeze) over a station must have been felt as a strongish wind. The average velocity of the air at False Point in November is 6·6 miles per hour and at Port Blair 6·9 miles per hour. The accounts of the passage of the calm central area shew that the air motion in it was not merely small compared with that of the previous hurricane winds, but that it was practically, if not absolutely, *nil*. It was, as described by the Light-housekeeper, a "dead calm followed after some time by light variable winds." It is hence certain that the apparent onward movement of the calm central area was not due to the forward translation of the contained mass of air. The False Point observations indicate that it was really due to the air immediately in front being brought to rest and as it were absorbed into the calm central area—whilst the action of the strong winds in the rear was to drag the air out of the neighbouring portion of the calm central area and put it into motion. Hence, as observed at False Point, the winds in front decreased rather rapidly, but by no means instantaneously, to moderate, thence to light winds, and in the rear the change occurred in the reverse manner. The calm central area is hence almost certainly transferred onwards in cyclones after the manner of a wave, by constant addition in front, and by diminution behind. The addition to the calm central area in front is evidently an effect of the rapid ascensional motion in front which experience has shown to be most vigorous in those tropical cyclones that have well-developed calm central areas.

If the inferences and reasoning in the preceding remarks be correct, it would also follow as a further consequence that the various actions determining the advance of the calm central area in the manner described would also tend to make the area of most active ascensional movement in the advancing quadrant move forwards in the same general direction. Its direction of advance would be determined by several causes some of which are stated in a later paragraph.

Hence in the words of Cleveland Abbe in his " Deductive Studies " " the position at any instant of the lowest barometer " (and it may be added of the calm central area in tropical cyclones in the Bay of Bengal) " is connected with the present portion of the region of the greatest updraft by a formula that represents a lagging behind, as in the problem of the dog chasing the fox, one is pursuing the other but never attaining."

Conditions determining track of storm.

Storms of the south-west monsoon originating in the Bay of Bengal, as a rule, travel along paths approximately coinciding with the position of the trough of minimum pressure at the time of their formation.

During the months of June, July, and August the trough of low pressure, as a rule, runs in a west-north-west direction from Orissa to Upper Sind or the South-West Punjab. It separates the area in which the Bombay branch of the monsoon current prevails from another in which the Bay current usually predominates. Westerly winds obtain in the former and easterly winds in the latter. The trough is a product of the circulation, and its position depends upon the relative strength of the two currents at the time. It is, as a rule, very distinctly marked in the months of June, July, and August.

When the rains cease or the monsoon humid current withdraws from North-Western India, the trough of low pressure is transferred south-eastward and fills up partially, and is a much less prominent feature of the meteorology of India in October and November than in the preceding months. It, however, continues to play a very important part in determining the line of march of cyclonic storms. The trough in the Bay in these months separates an area of westerly winds in the south of the Bay from an area in the north-west and north in which light to moderate easterly to north-easterly winds obtain. Its position is determined by the relative strength of these two air currents, and varies very considerably in the corresponding months of different years. Its normal position in November is the centre of the Bay between the Andamans and Nicobars on one side and the Coromandel Coast on the other.

Cyclonic storms during the months of October and November frequently originate in the central or eastern portion of this trough and advance along it usually with a slight additional northing, *i.e.* they tend to advance in west-by-north direction when the trough lies east and west across the Bay. When a storm forms in it, the humid south-west winds enter in the eastern quadrant, and the greatest ascensional movement usually occurs in the opposite quadrant and the storm centre advances towards this quadrant, and hence general westerly direction.

During the first-half of the advance of the Port Blair cyclone, from the 31st to the 2nd, it followed the normal track of cycl storms in the Bay in November, but during the latter half, from 3rd to 6th, it recurved to an abnormal extent.

Causes determining the recurvature of the storm.

The preceding discussion has established that the meteorolog October was marked by several abnormal features, which were only very persistent but were more strongly exhibited during the week of the month than before. The most important of these ab mal features was excessive pressure in the Deccan as contras with the eastern half of the Bay of Bengal and with the Bomba west coast districts. With these abnormal pressure features associated a preponderance of dry northerly winds in the north-w coast districts of the Bay instead of the normal north-east wi of the season. These abnormal winds accompanied a failur the October and November rains in the Deccan. South Ma received frequent rain during the month of October, thus show that the humid monsoon current was of at least moderate streng although considerably deflected and diverted from its normal ext sion. The rainfall in that area decreased rapidly in amount the 26th, and a considerable rise of pressure and an extension of area of local excessive pressure from the Deccan to South Mad hence occurred on the 29th and 30th. A reference to the sec Charts of Plates IV and V will shew clearly the characteristic featu of the pressure at this period.

The chief effect of these changes of pressure was to extend trough of low pressure eastwards into the Gulf of Siam, and to ca it to run in a westerly direction with a slight northing across centre of the Bay to the neighbourhood of the West Coast, wher was apparently blocked by the high pressure area in the Deccan.

The storm formed in the eastern extremity of the trough of pressure and advanced along a track a little more northerly than normal track in November across the Andaman Sea and the cen of the Bay of Bengal.

The recurvature was apparently due to the combination of following causes:—

1st.—The obstructive action of the East Ghâts.

2nd.—The barrier of local excess of pressure in the Deccan.

3rd.—The undue prevalence of land-winds in the north-west the Bay and the neighbouring coast districts.

The first cause is not a sufficient explanation, as the centre began to recurve when it was at a distance of at least 300 miles from the coast, and hence before the West Ghâts could have exerted any obstructive or deflecting influence on the storm.

The second and third causes are essentially one. The excess pressure in the Deccan was in part a cause and in part a product of the abnormal dry northerly winds in the Deccan and neighbouring part of the Bay of Bengal. The amount of the excess was relatively very small and apparently inadequate to act as an obstruction or barrier to a cyclonic storm of the magnitude and intensity of the Port Blair cyclone.

I have pointed out in a previous cyclone report that recurvature occurs when changes occur in the volume, and strength of the humid currents maintaining the cyclonic circulation. Thus storms of the rains passing across the head of the Peninsula, when they are maintained by the Bay current only, usually, if not invariably, recurve to north. In other words, the area of greatest uptake and most vigorous condensation takes place after a smaller amount of rotation or indraught than before. In such cases the volume of the humid winds of indraught decreases as it passes over the land area, and there is an increasing influence of dry land-winds. It is very probable that the latter exercise a considerable influence in diminishing the activity of condensation, and hence of the cyclone. The comparison of the storms referred to above with those of temperate regions where condensation is less vigorous than in tropical cyclones, confirms, the inference stated above that the increasing introduction of dry land-winds into the cyclone area tends to cause the most active condensation to occur earlier in the rotatory movement, and hence the centre to recurve to the right.

If the preceding argument be correct, the centre of the Port Blair cyclone began to recurve on the evening of the 2nd, because the winds of indraught to the westerly quadrant were much drier than usual. The recurvature was small at first, but on the 3rd, when the storm came more under the obstructive and deflecting influence of the East Ghâts, the recurvature increased rapidly.

The preceding statement has given the chief causes operative in determining the peculiar track of the Port Blair cyclone. They were—

1st.—The peculiar position of the trough of low pressure in the Bay at the time of formation of the storm.

2nd.—The effect of the undue prevalence of much drier and more northerly winds than usual in the north-west of the Bay (one indication of which was the excessive pressure in the Deccan) in causing a slow bend of the path of the centre to the right when approaching the coast of the Circars.

3rd.—The deflecting action of the East Ghâts on storms that advance obliquely towards them.

Origin of third storm.

The third storm was of moderate extent but of great intensity. It had a central calm area and an inner storm area of hurricane winds.

Unlike the Port Blair cyclone, it originated in the Bay, under what may be termed the ordinary conditions of cyclone generation in November. Southern India had a short burst of rain after the breaking up of the previous cyclone. Rain practically ceased on the 11th or 12th. Westerly winds continued in the south of the Bay, whilst north or north-east winds continued over the north-west and north. The trough of low pressure stretched across the centre of the Bay, and its form and position changed to some extent during the next few days. Weather became squally with much rain in the centre of the trough or slight depression. South-west winds in the south of the Bay increased in strength. These conditions continued from the 12th to the 17th or 18th without any indication of the initiation of a cyclonic storm. Favourable conditions apparently obtained during the whole of this period, but it was not until the 19th that the concentration commenced, which initiated and started the cyclonic whirl in the central portion of the shallow depression where previously squally and heavy weather with variable and unsteady winds had prevailed. The available information does not enable the cause of the change to be ascertained. It was undoubtedly connected with increasing rain in the area of disturbance and the advance and increasing strength of southerly humid winds in the south-east of the Bay. The conçentration may have been due to a localization of the rainfall in the area where the storm formed, or to the heavy rain squalls occurring over the area in such a manner as to give rise to the rapid accumulation of action and energy necessary to the rapid development of a large cyclonic whirl.

Rapid development of the storm.

The marine data prove that there was no regular cyclonic circulation in the centre of the Bay on the morning of the 18th. The first indications of the establishment of a cyclonic circulation were shewn on the morning of the 19th. It developed with great rapidity. experience of the ship *Mobile Bay* establishes that winds increased to hurricane force in the storm area on the afternoon of the 20th, and that there was a calm central area on the 21st. It hence almost certainly developed from the initial stage of irregular squally weather with no centre of action to an intense cyclonic storm with a calm centre in less than 48 hours.

Increase of extent of the storm area.

The history of the storm also shews that the extent of the storm (as measured by the area in which cyclonic winds force 8 and upwards prevailed) also increased rapidly. Thus on the 20th, winds of force 8 were almost certainly not felt at distances of 100 miles from the centre; on the 21st, winds of force 8 were experienced at distances varying from 150 to 250 miles; and on the 22nd at distances of at least 300 miles in the eastern quadrant. The data shew clearly that the storm increased in intensity and in extent, and that it commenced as a small central action in a large shallow depression area covering the centre of the Bay.

Track of the storm.

The following gives data of the position and rate of advance of the centre of the storm :—

	Latitude.	Longitude.	Distance travelled during previous interval.	Rate of motion in miles per hour.
20th, 8 A. M. . . .	11° 45′	87° 30′	...	...
21st, 8 „ . . .	12° 45	88° 30′	94	4
22nd, 8 „ . . .	14° 0′	89° 45′	118	5
23rd, midnight . . .	15° 30′	91° 15′	143	9
23rd, 8 A. M. . . .	16° 30′	93° 0′	133	17

The rate of advance of the storm hence increased steadily and rapidly from its formation on the 20th. Its rate, when approaching the Arakan Coast, was very probably at least 20 miles per hour. It may be noted that, as a rule, storms generated in the centre of the Bay increase in velocity as they advance, and that the increase of velocity is most marked in those storms which march northwards to the Head of the Bay or north-eastwards to Arakan.

Track of storm determined by the position of the axis of the trough of low pressure at the time.

A reference to the charts of the 19th and 20th will shew that in consequence of the change of pressure between the cessation of rain in Southern India on the 12th and the formation of the storm on the 19th and 20th, the trough of low pressure on these days formed a shallow depression over the centre of the Bay, the greatest diameter of which ran north-east and south-west. The path of the storm centre coincided closely with the axis or greatest diameter of this depression as shewn in the charts of the 19th and 20th, and hence in accordance with the general principle stated in pages 173-4.

Recurvature of the centre when approaching the Arakan Coast.

The storm recurved slightly to east on the 22nd and 23rd when it was approaching the Arakan Coast. In this case the recurvature was apparently due to the Arakan Hills diminishing to some extent the volume of the influx of humid winds, and the effect of this, as already explained, would be to cause it to recurve to the right of its previous direction of advance. A reference to the storm tracks given in the "Handbook of cyclonic storms in the Bay of Bengal" will shew that the two storms during the period 1882—87, which advanced from the centre of the Bay to the Arakan Coast, both recurved to east.

The path of the storm directed it almost directly to the Arakan Hills in the Sandoway district. The height of these hills ranges from 1,500 to 3,000 feet. It is interesting to contrast their action on the storm with that of the East Ghâts on the Port Blair cyclone. The Arakan Hills did not deflect the storm at all. As the storm was approaching them they acted more and more powerfully in breaking up the regular indraught of the humid winds in the eastern quadrant, and hence the storm was practically disintegrated by these hills. There passed over a shallow residual depression, which gave disturbed rainy weather and irregular winds for a short period of about 24 hours and then disappeared.

In the preceding discussion I have given a statement of all the more important features of the three cyclonic storms in the Indian seas during the month of November 1891, and have attempted to indicate the probable relations between the chief phenomena of the storms and also shown how far they were probably dependent upon antecedent meteorological conditions.

Summary of preceding discussion.

It has been pointed out that some of the more important features of the air movement in the largest of these storms, *viz.*, the Port Blair cyclone, cannot be explained on the ordinary assumption that the horizontal motion of the air can be considered as the resultant of a gyratory or rotatory velocity, and of a velocity of translation. The motion is much more complex. There was, for example, no perceptible movement of the mass of air in the calm central area, and it was propagated in exactly the same way as a wave in water is transmitted.

The occurrence of secondary or subsidiary whirls, and of a succession of violent squalls also indicate the presence of important irregular or intermittent actions during the storm at variance with the regular resolution of the air motion into two component parts. The air motion in different quadrants also differs largely in intensity and other features. Many of these peculiarities are at once explicable by the distribution and mode of occurrence of the rainfall in the storm area.

The data of the Port Blair cyclone suggest that in the most severe cyclones in the Bay vapour condensation and rainfall are most vigorous in the advancing quadrant. Pressure is sometimes, if not invariably, lowest at some little distance in front of the calm centre. This was shown fully by the observations taken at False Point during that cyclone.

The calm central area is transmitted forward by actions similar to those in a wave, and hence the transition from the hurricane winds of the inner storm area to the calm area is gradual, and not instantaneous. Mr. Willson in the report on the Midnapur cyclone of 1874 gives a striking example of this. He says: "Of the passage of the storm over the town of Burdwan I have seen various accounts, all of which differed more or less in the time given for the commencement of the gale and of its duration. It appears that before the gale the wind gradually decreased in violence until it was almost calm. The calm continued for about three quarters of an hour, and after that the wind gradually again increased until it reached nearly, if not quite, the same violence as before." These peculiarities of the air motion are important, as they indicate features not usually recognized and which are very probably essential conditions in cyclonic air motion in the Bay of Bengal and probably in the Tropics generally.

The three storms were all generated under similar circumstances. They were all disturbances in the humid south-west monsoon current. They all originated in sea areas under the influence of that current. They each formed during periods when the current was weak and had withdrawn temporarily from the land area of Southern India. The areas in which they formed were the northern or eastern limits of that current and were for some days previous to the generation of the storms, areas of light variable winds. North-east winds prevailed in the sea areas to the north and west, but these winds, as well as those of the south-west monsoon current, were light and feebler than the normal of the period. It is hence almost certain that the origin of these storms was not due to any mechanical action between two opposite air currents. The temperature conditions of the sea areas in which the storms originated, so far as they are indicated by the available observations, were almost certainly normal and very uniform, and it is hence very probable that these storms were not the development of temperature disturbances. The intimate relation between the rainfall accompanying the storms and the more prominent features has been fully stated, and it is evident that rainfall or aqueous vapour condensation formed by far the most prominent factor in determining the origin and motion of the three storms.

Variations in the strength and extension of the south-west monsoon current are normal features of its existence. These variations are most marked when the current is retreating. Cyclones in the months of October, November, and December originate in the intervals known as breaks in the retreating south-west monsoon rains in Southern India, and hence when the current is feeble. The usual antecedent conditions are uniform pressure and temperature conditions in the Bay, the prevalence of light and variable winds over a large portion of the Bay and of feeble to moderate unsteady south-west winds in the south of the Bay. Fine clear weather usually obtains, and hence evaporation under a tropical sun proceeds rapidly. Frequently, after these conditions have continued for some little time, weather becomes showery and slightly disturbed in a portion of the area; usually that in which winds are lightest and most unsteady and variable. The rainfall increases in amount and becomes more localized and concentrated, and the weather becomes squally. If the conditions favour the continued concentration of the rainfall, the disturbance passes beyond the diffused irregular stage of squally weather and a regular cyclonic circulation is rapidly established. The whole of the changes are such as may occur in consequence of the ordinary dynamical changes constantly in progress in the atmosphere. The potent factor in the Bay is aqueous vapour condensation, and any conditions that favour the peculiar distribution of rainfall essential for the initiation or development of the area may be determining conditions. It is not necessary to repeat them as they have been sufficiently indicated in the preceding discussion. Cleveland Abbe in his "Preparatory studies for deductive methods in storm and weather predictions" has explained very fully the origin of storms under similar conditions in the United States (pages 144—8). The following extract gives a very clear and interesting account of the earlier stages of the formation and development of this class of cyclonic storms in the United States :—

> "By the velocities and directions of the clouds and winds we shall know that such a new controlling central indraught has been formed. There is first a diminution of wind velocities in certain directions, and then such reversions or such other modifications of these directions as make them conform to a general circulation about the central region. This new arrangement of winds and cloud movements becomes apparent first in the cloud, and is slowly propagated down to the earth's surface until this new circulation is well established among the lower winds,

and until then we observe no great fall in the barometer. The uprising of air, or the fall of rain, or the straight line indraught can, as has been frequently shown. have no appreciable, or rather only a very evanescent, barometric influence. The buoyancy can initiate and maintain movements to which the limpid air responds so quickly that a gradient of 0·01 of an inch of pressure for a degree of a great circle will suffice to explain our heaviest winds; but when a movement has once begun in response to such slight gradient there comes into play a centrifugal action and a force depending on the rotation of the earth, deflecting the currents to the right and leaving a decided depression at the place of central indraught. No sooner has the wind begun to rotate or circulate about this centre than there arises still another centrifugal force due to the rotation about this storm centre, by virtue of which the barometric pressure is still further reduced, thus giving rise to barometric phenomena as we ordinarily observe them. In this way our so-called storm centre, when once started, is fed and grows, and if the condensation of vapour, or the sunshine, or the excessive rainfall, or the descent of dry air on one side of the storm, one or all conspire to tend to develop a buoyancy in the atmosphere on one side of the centre greater than on the other side, then the storm will be propagated in that direction."

The conditions determining the line of march, the unusually large recurvature, and rapid disintegration of the Port Blair cyclone have been fully discussed. The formation of the storm in the eastern portion of the retreating south-west monsoon trough of low pressure, its westward march along this trough (with the usual tendency to deviate slightly to the right), and the large deflection of the storm, in part due to the abnormal pressure in the peninsula and in part to the obstructive action of the West Ghâts, have been explained in the preceding paragraphs and the dominating influence of rainfall on each of these features set forth.

Cleveland Abbe in page 130 of his " Preparatory Studies " gives the following actions or causes as determining the motion of cyclones in the United States:—

(1.) The unbalanced northward pressure attending a "low " as deduced by Farrel.
(2.) The drift of the general current of atmosphere that carries the air and the storm along together.
(3.) The insolation that stimulates uprising currents on the sunny side.
(4.) The orography that promotes cloud growth and rain on the windward side of mountains and coasts.
(5.) Oceans that promote evaporation.
(6.) The geographical distribution of the areas of high pressure.
(7.) The precipitation of rain that leaves heat free in the cloud.

He also adds, "Of all these, the last (7) when it occurs becomes at once the leading factor in determining the progress of the whole disturbance."

In the case of the storm under discussion, the motion was in no way determined by the drift of the atmosphere. The third and fourth causes exercised some slight influence. The fifth was probably influential in contributing to the origin as well as the march of the storms. The sixth in the case of Indian cyclones is of much importance and should perhaps be stated in the case of these cyclones as follows:—

Cyclones in the Indian area have a strongly marked tendency to advance along troughs of low pressure and towards low-pressure areas, and hence their tracks are largely determined by the geographical distribution of the areas of high and low pressure at the time of their formation and occurrence.

The history of all large cyclones in India shows that rainfall becomes the dominating factor in the earlier, if not the earliest stages of the storm and that it continues to be the leading factor throughout the whole existence of these storms.

APPENDIX A.

The following gives the whole of the actual observations as recorded at the False Point Light House Observatory and the Port Office Hookeytollah, during the storm :—

Actual observations as recorded at the Light House, False Point, during the storm of the 4th, 5th and 6th November 1891.

Date.	Hour.	Barometer.	Attached thermometer.	Hygrometer.		Wind direction.	Cloud amount.	Lower clouds.		Rainfall since preceding observation of rain.	Weather remarks.
				Dry Bulb.	Wet Bulb.			Kind.	Moving from		
5th Nov. 1891.	8-30 A.M.	29·716	79	...	...	E.	10	Pk.	E.	...	Blowing a gale with heavy rain, weather very threatening.
	9 A.M.	·714	79	...	...	E.	10	Pk.	E.-S.-E.	...	Severe puffs, clouds and scud drifting fast.
	9-30 A.M.	·706	79	...	...	E. S. E.	10	Pk	E.-S.-E.	...	Wind increasing; blowing a hard gale.
	10 A.M.	·680	79	79·0	76·8	E. S. E.	10	Pk.	S.-E.	...	Weather conditions unaltered.
	10-30 A.M.	·646	79	...	...	S. E.	10	Pk.	S.-E.	...	Severe gale with blinding rain.
	11 A.M.	·632	79	79·0	76·8	E. S. E.	10	Pk.	S.-E.	...	Terrific squalls with heavy rain.
	11-30 A.M.	·556	79	...	...	E. S. E.	10	Pk.	S.-E.	...	Hard gale with blinding rain.
	Noon	Readings omitted, being engaged in changing anemometer.									
	12-30 P.M.	·436	79	...	...	...	..	...	...	...	Wind increasing, 68 miles hourly velocity by the new anemometer. Heavy clouds travelling at an enormous rate.
	1 P.M.	·370	79	...	..	E. S. E	10	Pk.	S.-E.	...	Wind blowing with hurricane force, rain blinding.
	1-30 P.M.	·276	78	...	...	New anemometer blown away.	10	Pk.	S.-E.	...	Weather conditions the same.
	*2 P.M.	·150	78	76·2	76·0	S. E.	10	Pk.	S.-E.	1·60	Continuation of severe weather, barometer commenced pulsating.
	2-30 P.M.	28·778	78	...	...	S. E.	10	Pk.	S.-E.	...	Wind heavy and most terrific with blinding rain.
	3 P.M.	·476	77	...	...	S. E.	10	Pk.	S.-E.	...	Weather conditions unchanged.
	3-30 P.M.	·300	77	...	...	E. S. E.	10	Pk.	E.-S.-E.	...	Wind still fierce, barometer pulsating about tenth of an inch.
	3-45 P.M.	·132	78	...	...	...	...	...	...	...	Clouds not so dense, centre apparently near. The barometer stood for a short time and then commenced to rise, pulsating violently.
	4 P.M.	·204	78	77·0	77·0	E. S. E.	10	Pk.	E.-S.-E.	...	Wind blowing a moderate gale, rain decreasing; breaks in clouds.
	4-5 P.M.	...	...	...	...	...	.	...	...	...	The wind ceased, and then a dead calm followed by light variable winds which lasted till 4-45 P.M.
	4-15 P.M.	·242	78	...	...	S. E.	10	Pk.	...	...	Light winds. Broken clouds; heavy banks to eastward.

*** After the 2 P.M. observations were taken, the thermometers were removed to the Light House verandah for safety.**

Actual observations as recorded at the Light House, False Point, during the storm of the 4th, 5th and 6th November 1891—concld.

Date.	Hour.	Barometer.	Attached thermometer.	Hygrometer.		Wind direction.	Cloud amount.	Lower clouds.		Rainfall since preceding observation of rain.	Weather remarks.
				Dry Bulb.	Wet Bulb.			Kind.	Moving from		
5th Nov. 1891.	4-30 P.M.	·286	78	...	...	N. W.	10	Pk.	...	...	Weather appearances about the same.
	5 P.M.	·300	79	77·0	77·0	N. W.	10	Pk.	...	2·16	Blowing a hurricane with blinding rain.
	5-30 P.M.	·606	77	...	...	N. W.	10	Pk.	...	...	The force of the wind at this time was terrific.
	6 P.M.	·916	78	...	...	N. W.	10	Pk.	...	...	Weather conditions about the same.
	7 P.M.	29·198	78	...	...	N. W.	...	...	...	...	Wind moderating a little, continuous heavy rain.
	8 P.M.	·522	78	...	...	N. W.	10	Pk.	...	1·42	Wind gradually moderating and rain decreasing still blowing a hard gale.
	9 P.M.	·660	78	...	...	N. W.	...	...	...	...	Moderate gale; light rain.
	10 P.M.	·772	78	..	...	N. W.	10	Pk.	N. W.	...	Strong wind; rain nearly ceased, clouds less dense.
	11 P.M.	·840	78	74·0	72·0	N. W.	10	Pk.	N. W.	0·50	Weather continuing about the same.
	Midnight	·852	77	...	...	N. W.	10	Fk.	N. W.	...	Wind decreasing in force, drizzling rain.
6th Nov. 1891.	2 A.M.	·842	77	74·0	72·0	N. W.	10	Fk.	N. W.	0·15	Dark gloomy weather with fresh winds, rain ceased; clouds breaking.
	5 A.M.	·844	77	74·1	74·0	...	8	Fk.	N. W.	...	Weather looking gloomy, but clearing up; moderate breeze.

APPENDIX B.

Actual observations as recorded at the Port Office (Hookeytollah) False Point, during the storm of the 4th, 5th and 6th November 1891.

Day and date.	Hours.	Barometer (aneroid).	Thermometer.	Wind.	State of the weather.
Wednesday 4th Nov. 1891.	6 A.M.	29·72	84	N.-E.	Blowing a hard gale with heavy squalls of wind and rain, wind veering between north-east and east.
	8 A.M.	29·75	82	„	Ditto weather.
	10 A.M.	29·76	82	„	Ditto ditto with heavier rain.
	11 A.M.	29·74	83	„	Ditto ditto ditto.
	Noon.	29·70	83	„	Still blowing a hard gale, but squalls not so frequent or so fierce.
	1 P.M.	29·67	84	„	Blowing a hard gale with a heavy overcast sky and ugly looking weather, with a very heavy sea in the Bay.
	2 P.M.	29·63	83	„	Ditto weather, with very heavy squalls and showers of rain.
	3 P.M.	29·63	82	„	Ditto ditto.
	4 P.M.	29·63	82	„	Ditto ditto.
	5 P.M.	29·63	82	„	Ditto ditto with very fierce squalls.
	6 P.M.	29·64	82	„	Ditto ditto.
	7 P.M.	29·64	81	„	Ditto ditto with heavy rain.
	8 P.M.	29·66	82	„	Ditto ditto squalls more fierce and frequent.
	9 P.M.	29·67	83	„	Ditto ditto.
	10 P.M.	29·67	83	„	Ditto ditto with lightning to the south-east.
	11 P.M.	29·65	83	„	Ditto ditto ditto.
	Midnight.	29·63	83	„	Ditto ditto ditto.
Thursday 5th Nov. 1891.	1 A.M.	29·60	83	„	Blowing a hard gale, with very fierce squalls, blinding sheets of rain, flashes of lightning to the south-west and distant thunder and a dull leaden overcast sky.
	2 A.M.	29·60	83	„	Ditto weather with wind veering between north-east and east.
	3 A.M.	29·59	83	„	Ditto ditto.
	4 A.M.	29·59	83	„	Ditto ditto.
	5 A.M.	29·58	83	„	Ditto ditto; 5-30 A.M. wind suddenly lulled and became almost a calm for nearly half an hour, but at 6 A.M. wind squalls commenced afresh with blinding sheets of rain.
	6 A.M.	29·56	83	„	Ditto weather, with wind veering between north-east and east.
	7 A.M.	29·56	83	„	Ditto weather.
	8 A.M.	29·56	83	„	Ditto.
	9 A.M.	29·56	83	„	Ditto.
	9-15 A.M.	29·56	84	East.	A most terrific squall from the east with blinding sheets of rain.
	9-30 A.M.	29·55	84	East.	Ditto weather.
	9-45 A.M.	29·55	84	„	Ditto.
	10 A.M.	29·53	84	„	Ditto.
	10-15 A.M.	29·51	84	„	Ditto.
	10-30 A.M.	29·50	84	E. S. E.	Wind increased to a hurricane with very severe squalls of wind and rain.
	10-45 A.M.	29·50	81	E. S. E.	Ditto weather.
	11 A.M.	29·50	84	„	Ditto.
	11-15 A.M.	29·50	84	„	Ditto.
	11-30 A.M.	29·49	84	„	Ditto.
	11-45 A.M.	29·46	84	„	Ditto.
	Noon.	29·44	84	„	Ditto.
	0-15 P.M.	29·44	84	„	Ditto.

Actual observations as recorded at the Port Office (Hookeytollah) False Point, during the storm of the 4th, 5th and 6th November 1891—concluded.

Day and date.	Hours.	Barometer (aneroid).	Thermometer.	Wind.	State of the weather.
Thursday 5th November 1891 —*contd.*	0-30 P.M.	29·38	84	E.-S.-E.	Wind increased to a hurricane with very severe squalls of wind and weather.
	0-45 P.M.	29·35	84	,,	Ditto.
	1 P.M.	29·31	83	,,	Ditto.
	1-15 P.M.	29·29	83	,,	Ditto.
	1-30 P.M.	29·26	83	,,	Ditto.
	1-45 P.M.	29·23	83	,,	Blowing a violent hurricane with most terrific squalls and blinding sheets of rain.
	2 P.M.	29·17	83	,,	Ditto weather.
	2-15 P.M.	29·10	82	,,	Ditto.
	2-30 P.M.	29·05	82	,,	Ditto.
	2-45 P.M.	28·95	82	,,	Ditto.
	3 P.M.	28·85	83	,,	Ditto.
	3-15 P.M.	28·74	84	,,	Ditto.
	3-30 P.M.	28·65	84	E. S. E.	Blowing a most violent hurricane with most terrific squalls and blinding sheets of rain.
	3-45 P.M.	28·55	82	,,	Ditto weather.
	4 P.M.	28·37	82	,,	Ditto 4-12 P.M., wind suddenly lulled and blew in heavy gusts, the centre of the storm evidently passing close to the eastward of us.
	4-15 P. M.	28·22	82	,,	Moderate breeze with heavy rain and a very heavy overcast sky and thick hazy weather.
	4-20 P. M.	28·20	82	N. E.	Ditto weather.
	4-30 P. M.	28·20	82	,,	Ditto.
	4-40 P. M.	28·15	82	,,	Ditto.
	4-50 P. M.	28·15	82	,,	Ditto.
	5 P. M.	28·15	82	North.	Ditto.
	5-10 P. M.	28·17	82	,,	Strong breeze with heavy gusts and
	5-20 P. M.	28·22	82	,,	Ditto weather. Ditto weather.
	5-30 P. M.	28·26	82	,,	Wind increased to a hard gale with heavy squalls and blinding sheets of rain.
	5-40 P. M.	28·35	82	N. W.	B wing a violent hurricane with most terrific squalls and blinding sheets of rain.
	5-50 P. M.	28·40	82	,,	Hurricane blowing with redoubled force Ditto weather.
	6 P. M.	28·53	82	,,	Ditto weather.
	6-10 P. M.	28·65	82	,,	Hurricane blowing with redoubled force, most terrific squalls and blinding sheets of rain.
	6-20 P. M.	28·73	82	,,	Ditto.
	6-30 P. M.	28·77	82	W.	Ditto.
	6-40 P. M.	28·86	82	,,	Ditto.
	6-50 P. M.	28·91	82	,,	Ditto.
	7 P. M.	28·96	82	,,	Wind moderating slightly, but still blowing with hurricane force, squalls not quite so terrific.
	7-10 P. M.	29·00	82	,,	Ditto.
	7-20 P. M.	29·03	82	,,	Ditto.
	7-30 P. M.	29·10	82	W.-S.W.	Ditto.
	7-40 P. M.	29·15	82	,,	Ditto.
	7-50 P. M.	29·18	82	,,	Ditto.
	8 P. M.	29·20	82	,,	Ditto.
	8-15 P. M.	29·25	82	W. S. W.	Windlmod erated to a hard gale with heavy squals of wind and rain.
	8-30 P. M.	29·34	82	,,	Ditto weather.
	8-45 P. M.	29·36	82	,,	Ditto.
	9 P. M.	29·40	82	,,	Ditto.
	9-30 P. M.	29·47	82	,,	Ditto.
	10 P. M.	29·53	82	S. W.	Wind moderated to a moderate gale with occasional squalls of wind and rain and a heavy overcast sky.
	Midnight.	29·63	82	S. W.	Strong breeze, cloudy and fine weather.
Friday 6th Nov. 1891.	4 A. M.	29·65	82	N. W.	Light winds, cloudy and fine.
	8 A. M.	29·77	79	North.	Light weather, with heavy banks of clouds to the east and south-east.

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CHART I.—MEAN DAILY DISTRIBUTION OF PRESSURE OF THE MONTH OF OCTOBER.

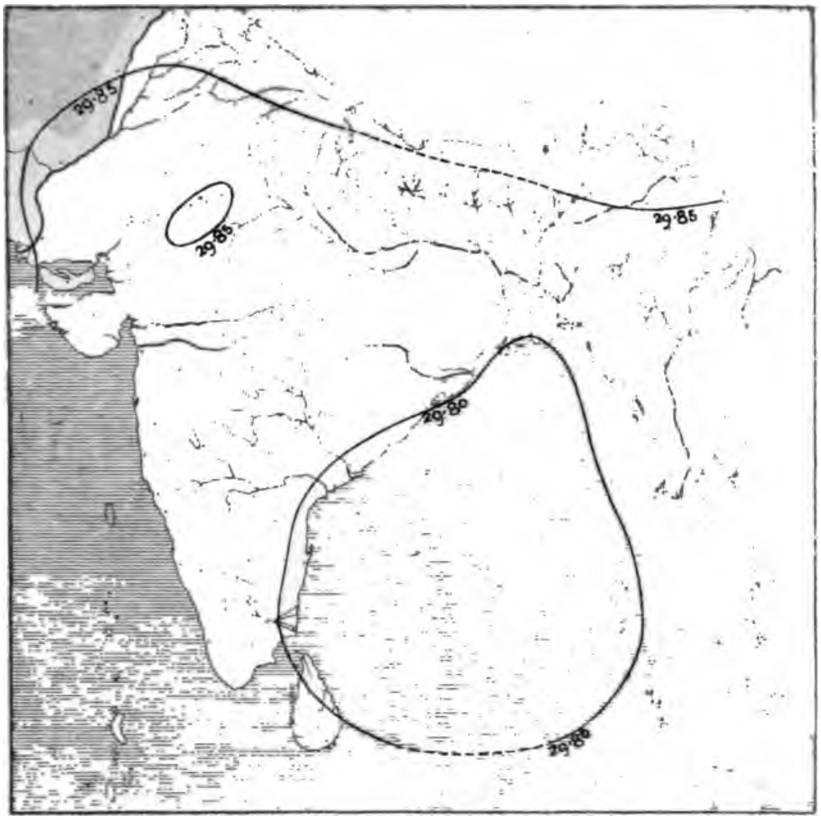
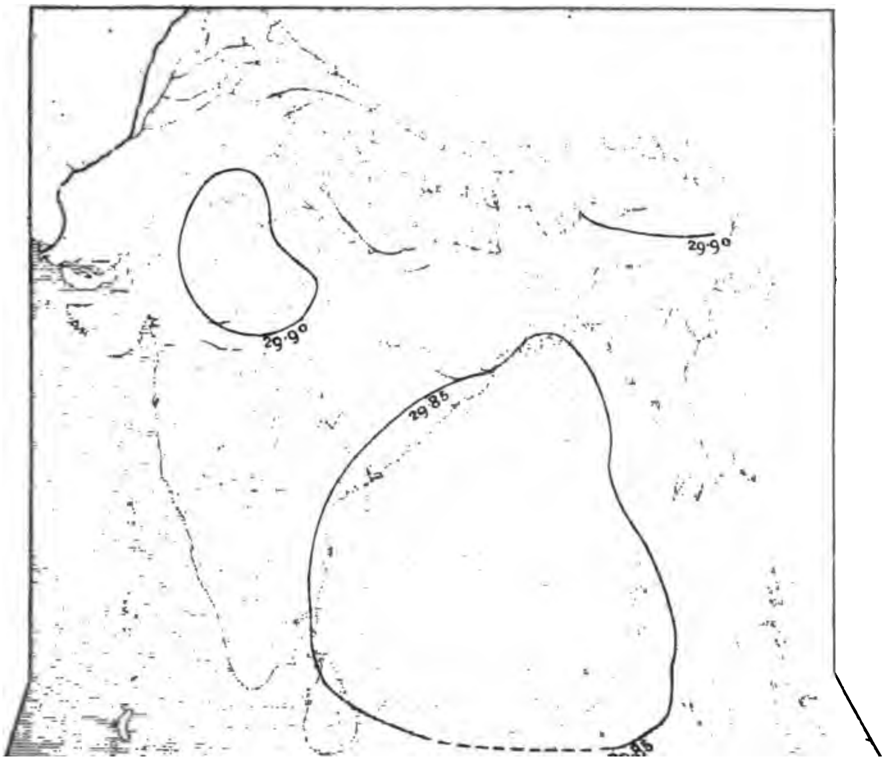


CHART II.—MEAN 8 A.M. DISTRIBUTION OF PRESSURE IN THE MONTH OF OCTOBER.



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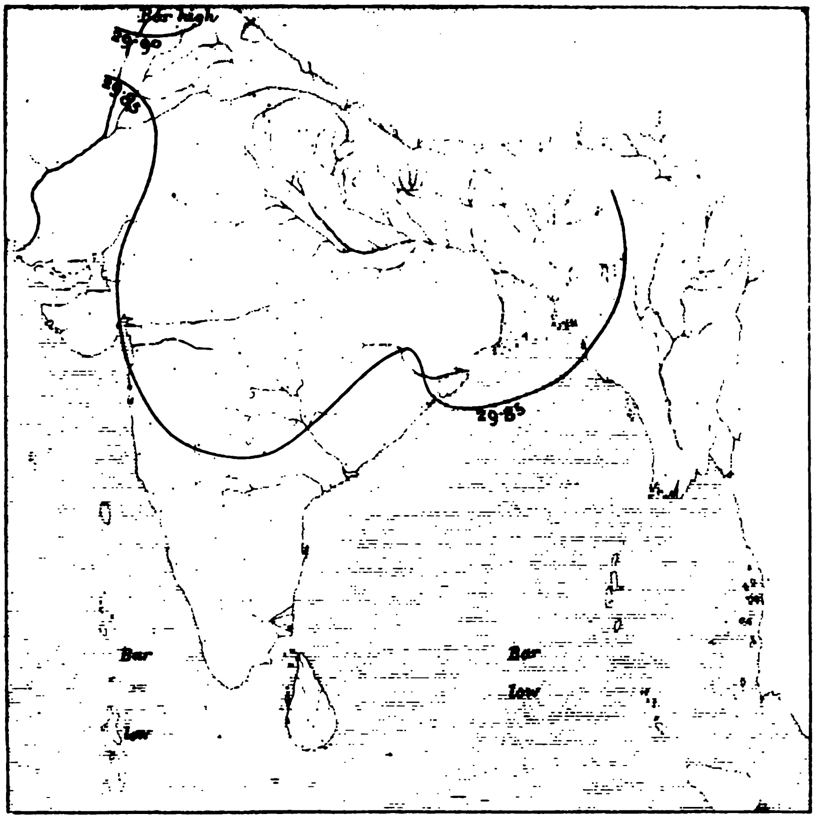

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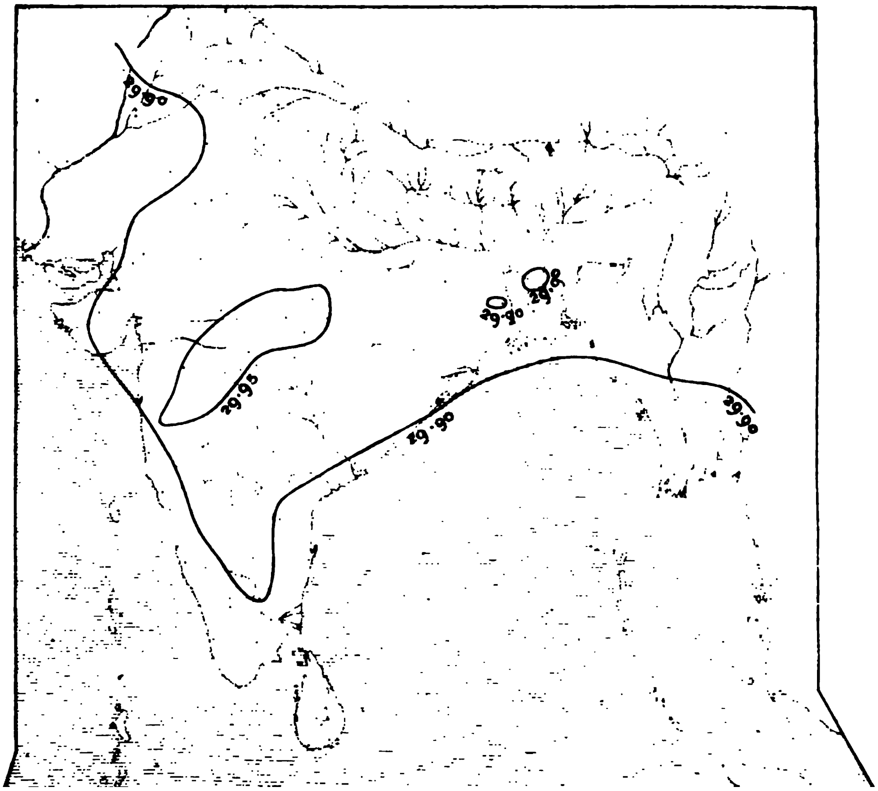

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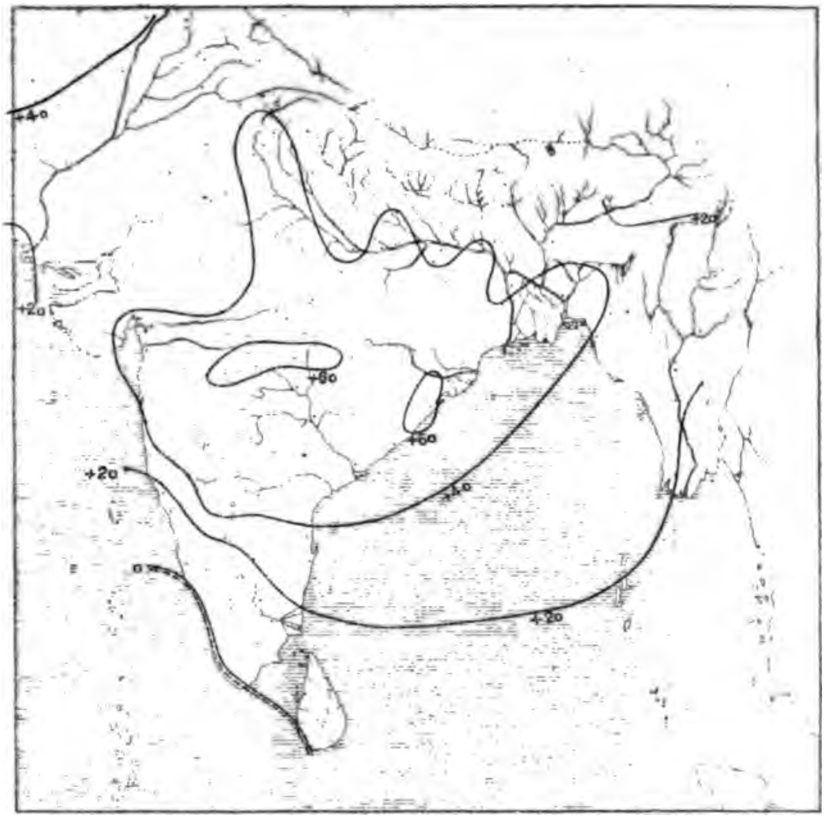

CHART II.—DISTRIBUTION OF THE PRESSURE ANOMALIES OR LOCAL VARIATIONS OF PRESSURE IN OCTOBER 1891.

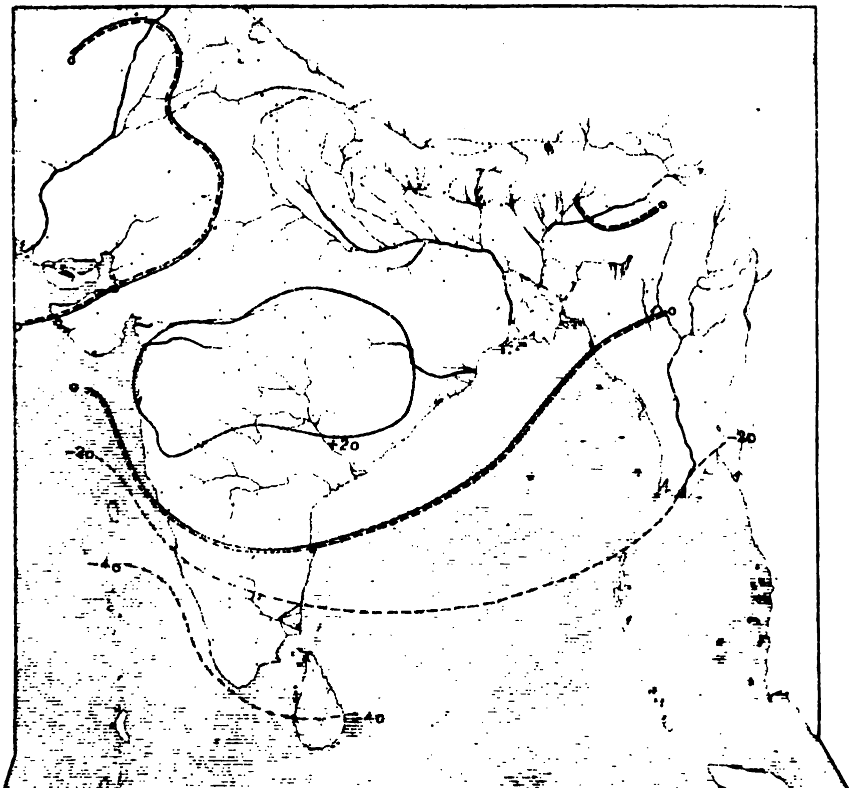

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CHART I.—WEATHER CHART OF INDIA FOR 30th OCTOBER 1891, SHEWING PRESSURE DISTRIBUTION AND WINDS.

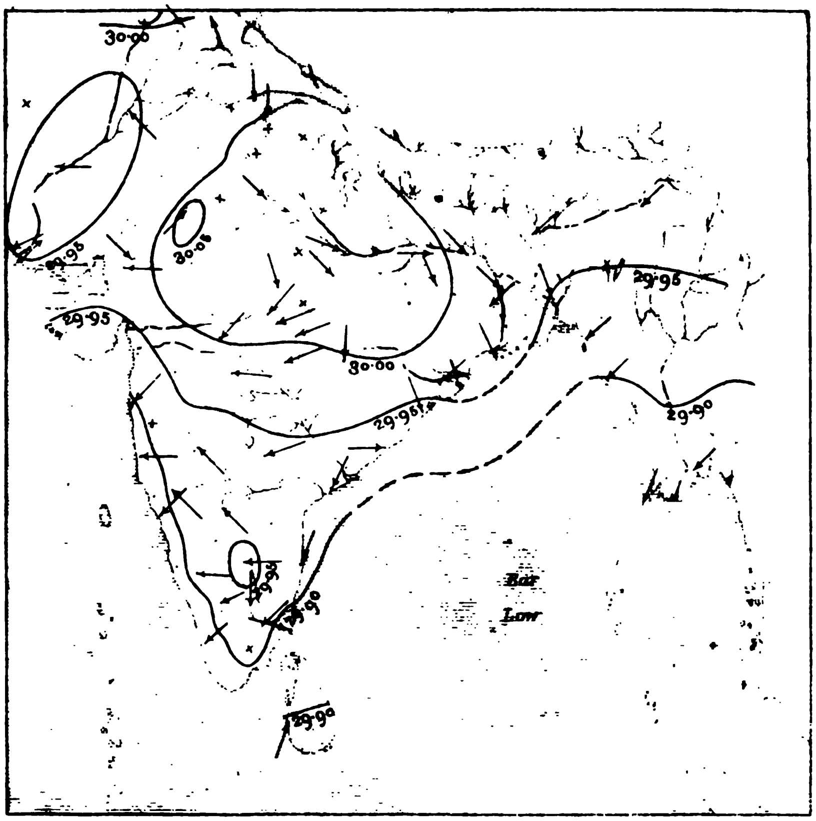

CHART II.—CHART SHEWING DISTRIBUTION OF PRESSURE ANOMALIES, 30th OCTOBER 1891.

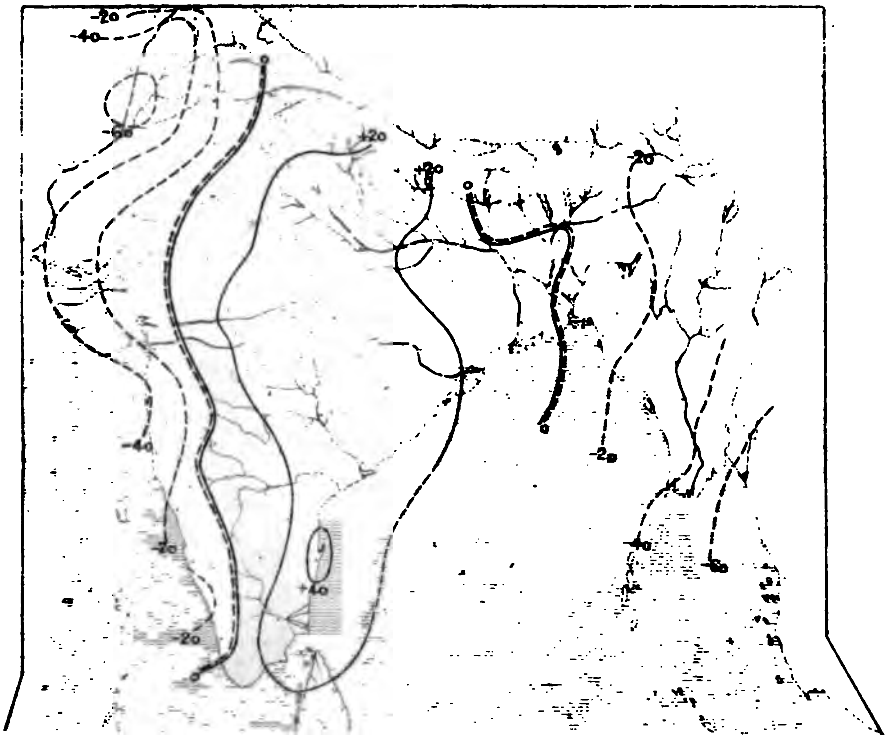

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CHART I.--WEATHER CHART OF INDIA FOR 31st OCTOBER 1891 SHEWING PRESSURE DISTRIBUTION AND WINDS.

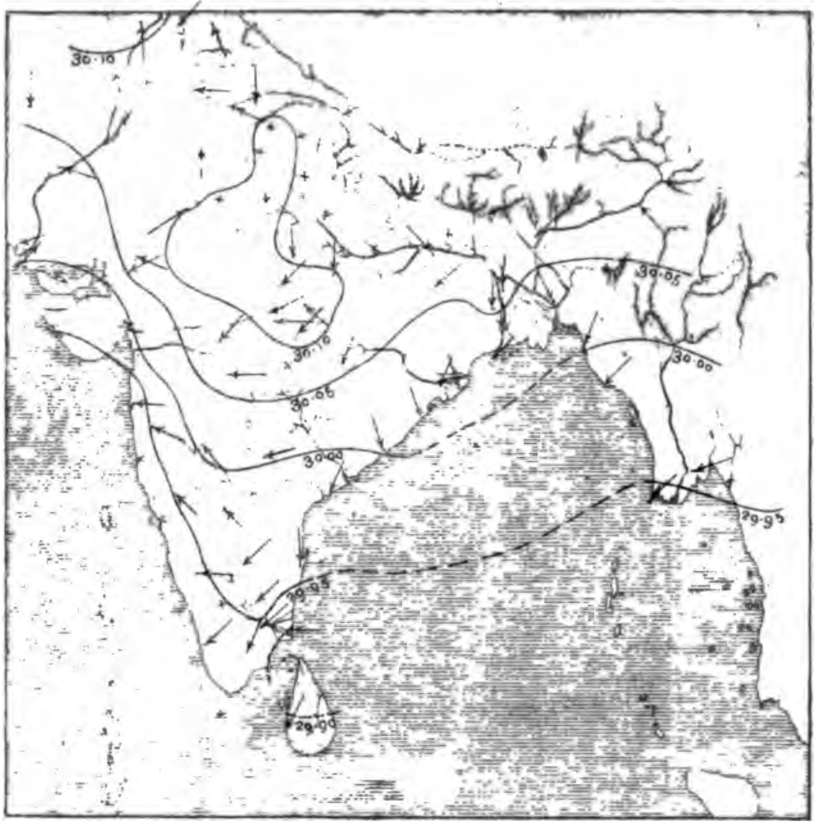
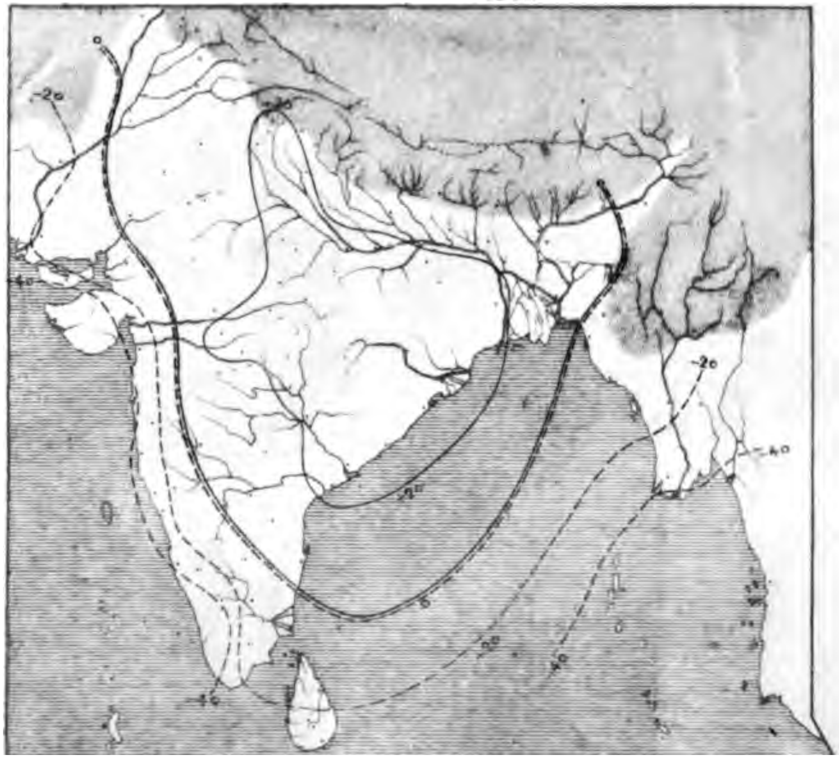


CHART II.--CHART SHEWING DISTRIBUTION OF PRESSURE ANOMALIES, 31st OCTOBER 1891.



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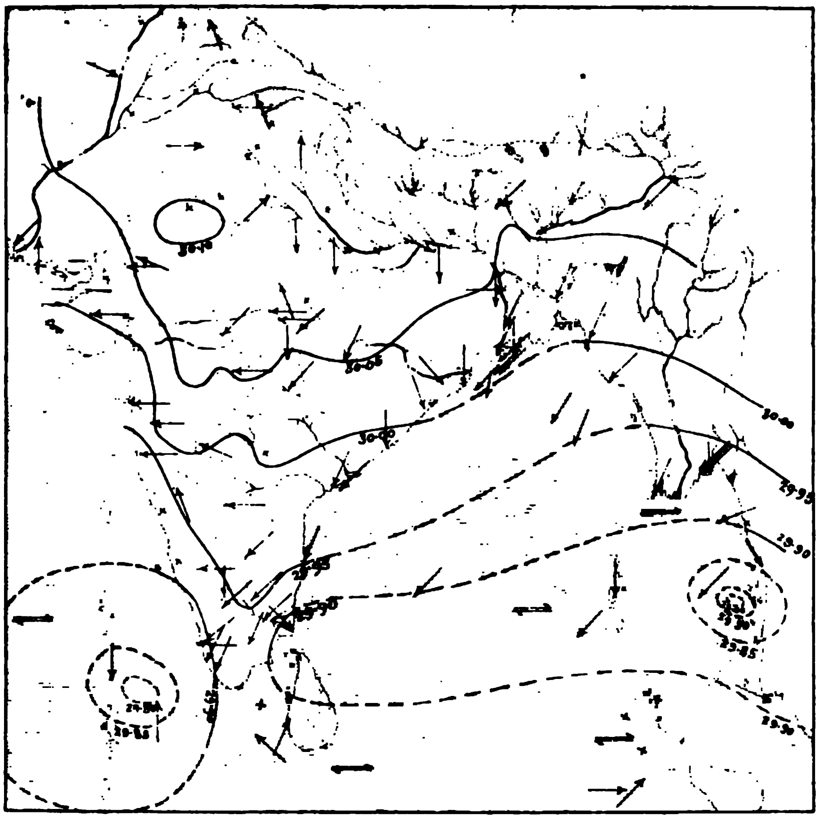

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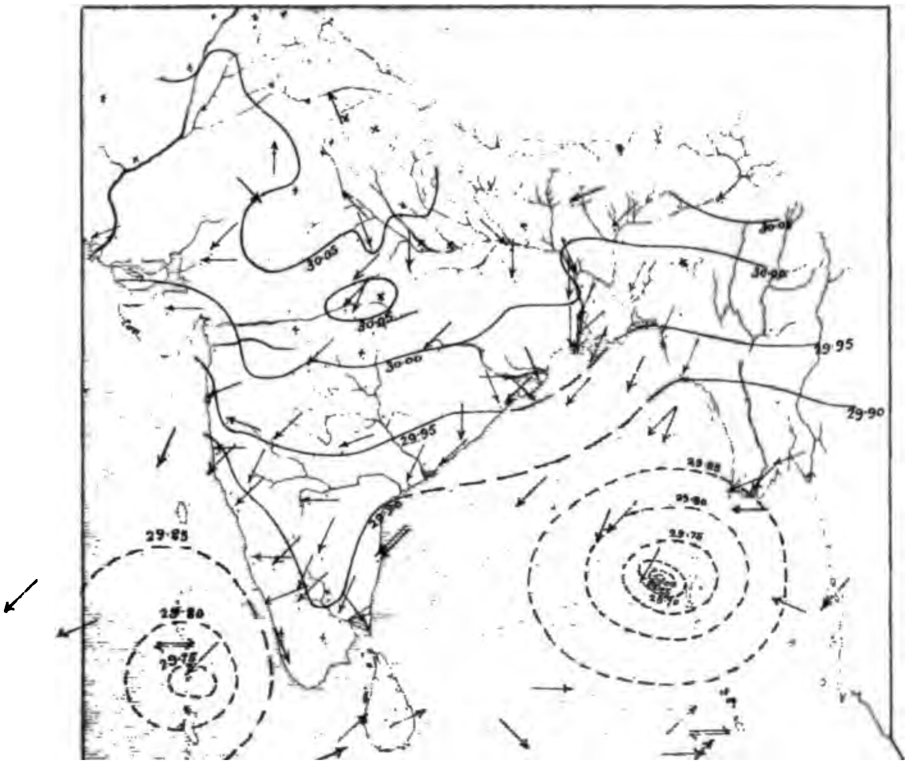

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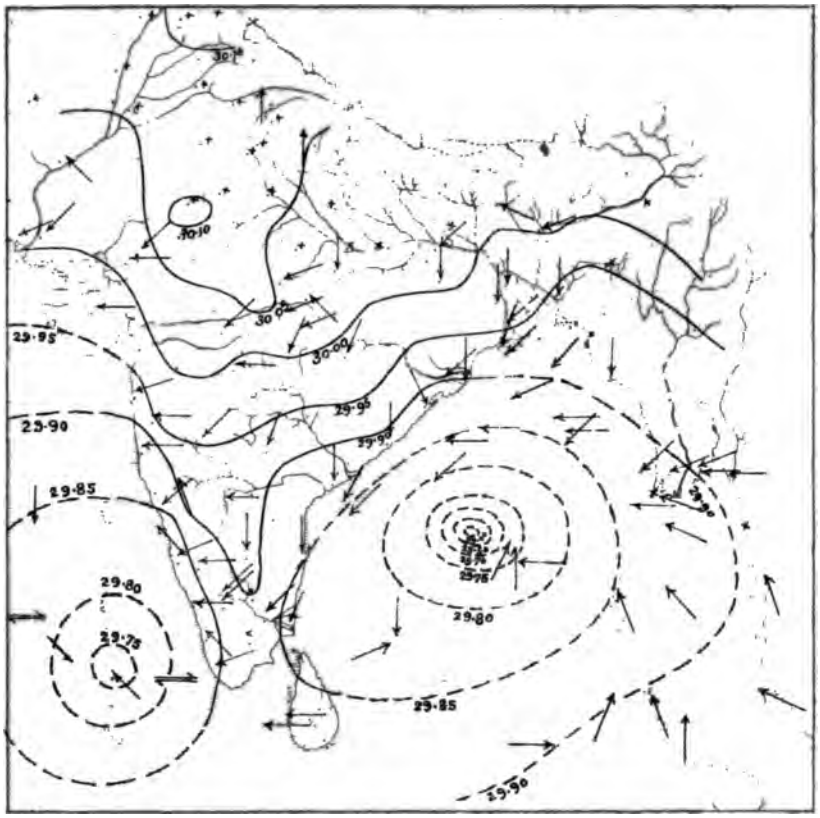
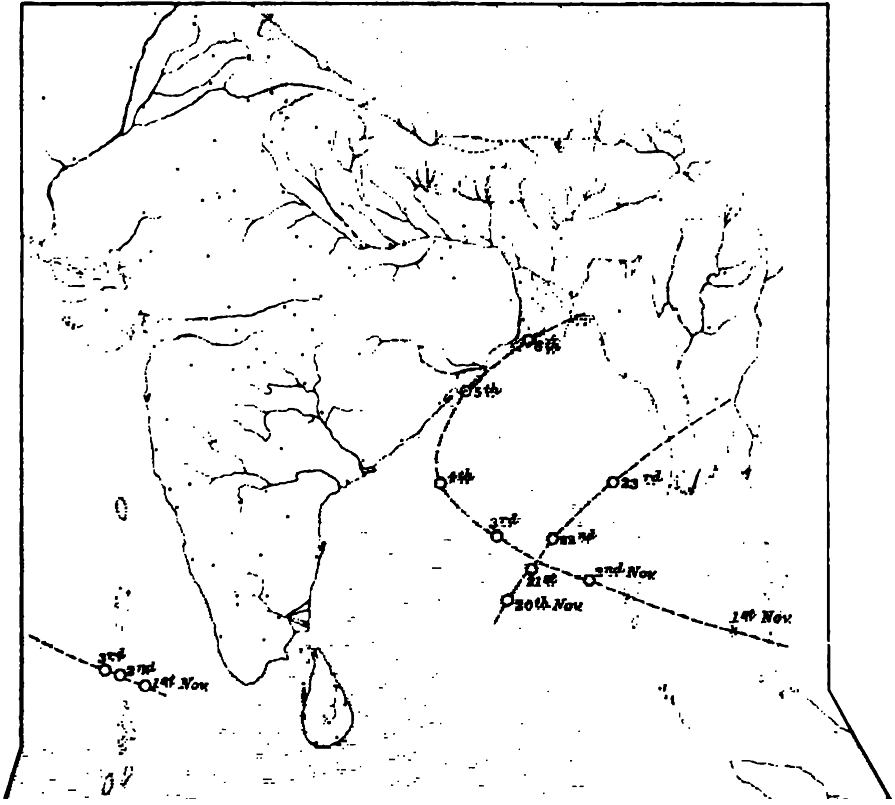


TRACKS OF CYCLONIC STORMS IN THE BAY OF BENGAL AND ARABIAN SEA, NOV. 1891.



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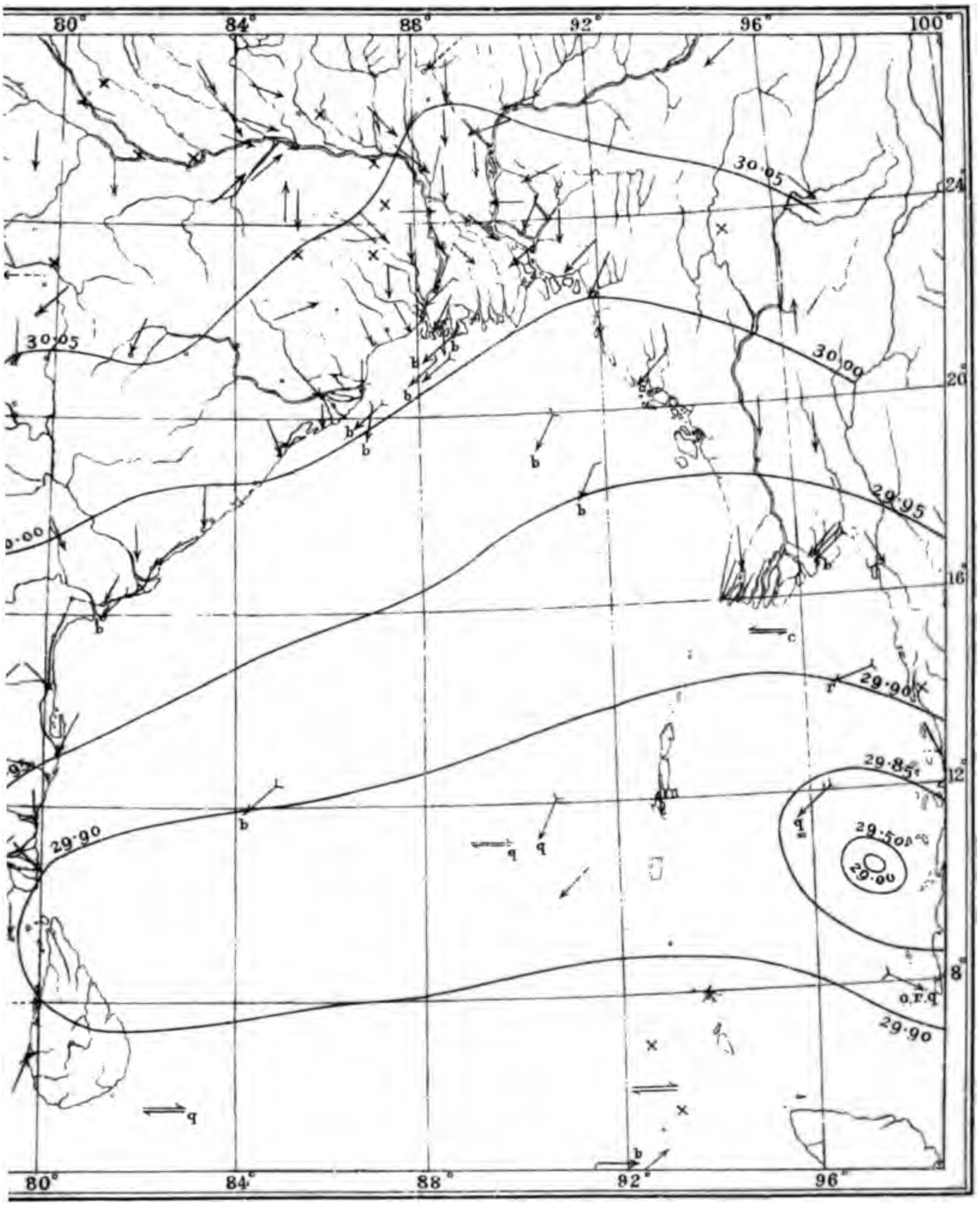

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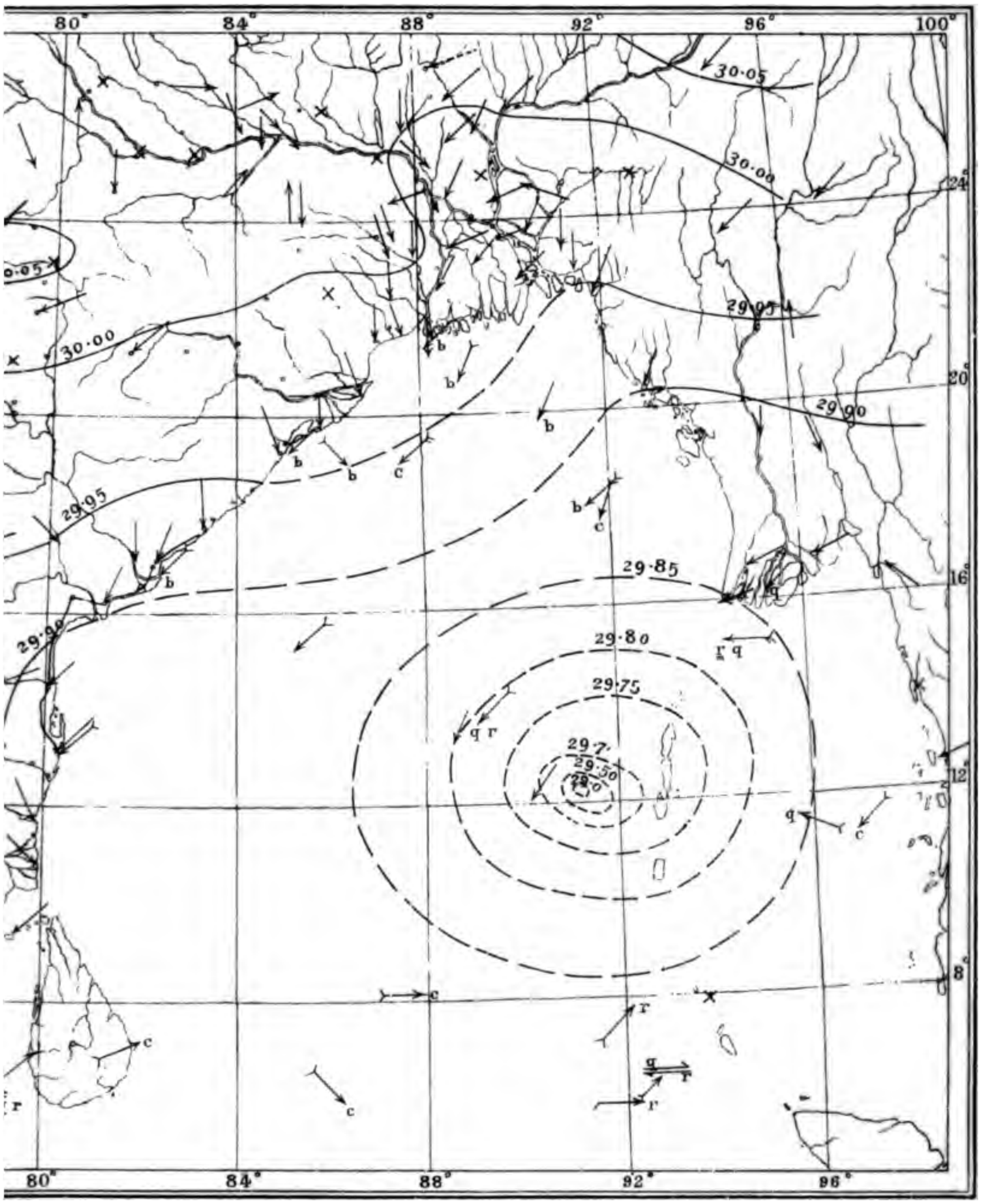
Plate IX.

WEATHER CHART OF THE BAY OF BENGAL, 2nd NOV. 1891.



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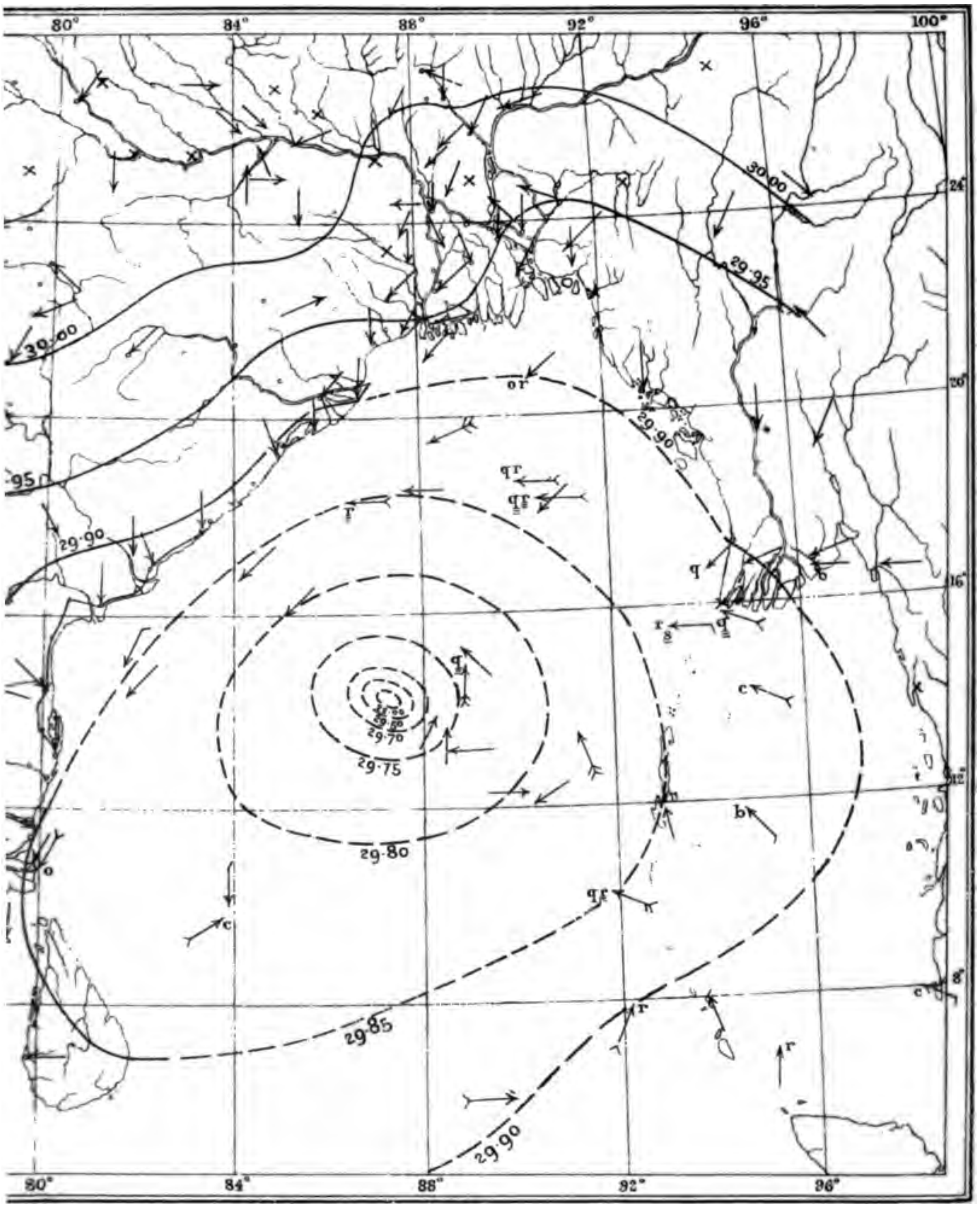

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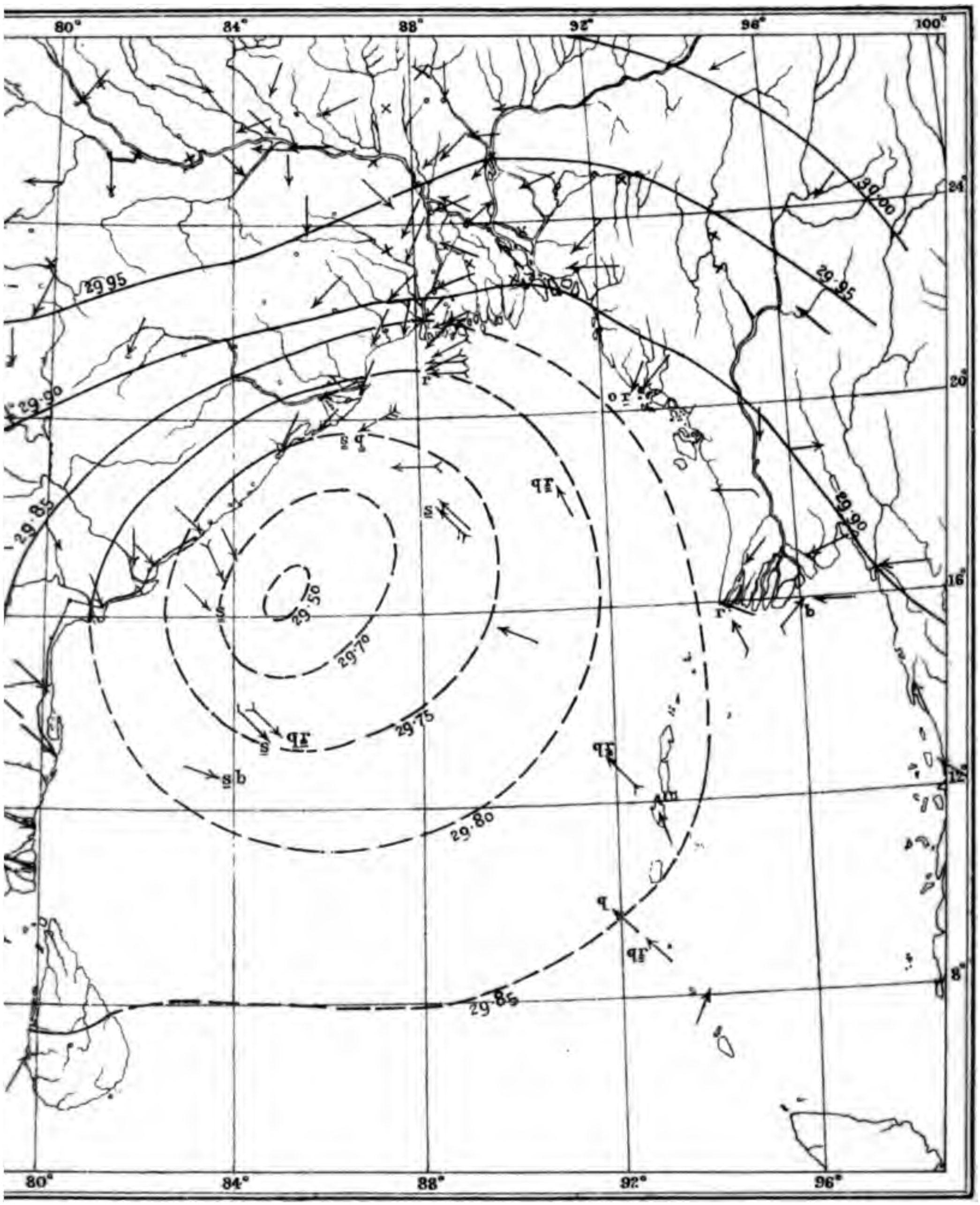
Plate XI.

WEATHER CHART OF THE BAY OF BENGAL 4th NOV. 1891.



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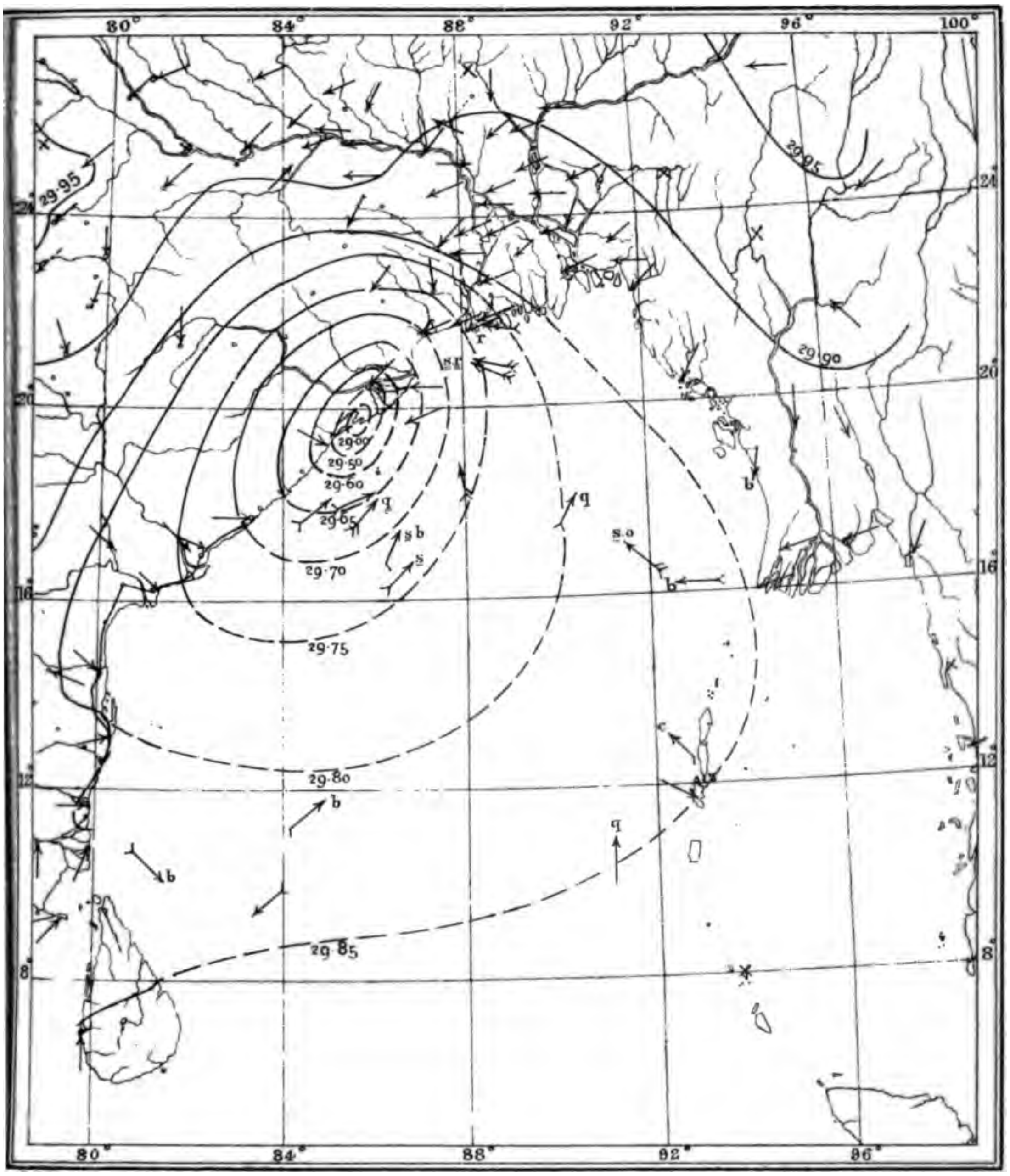

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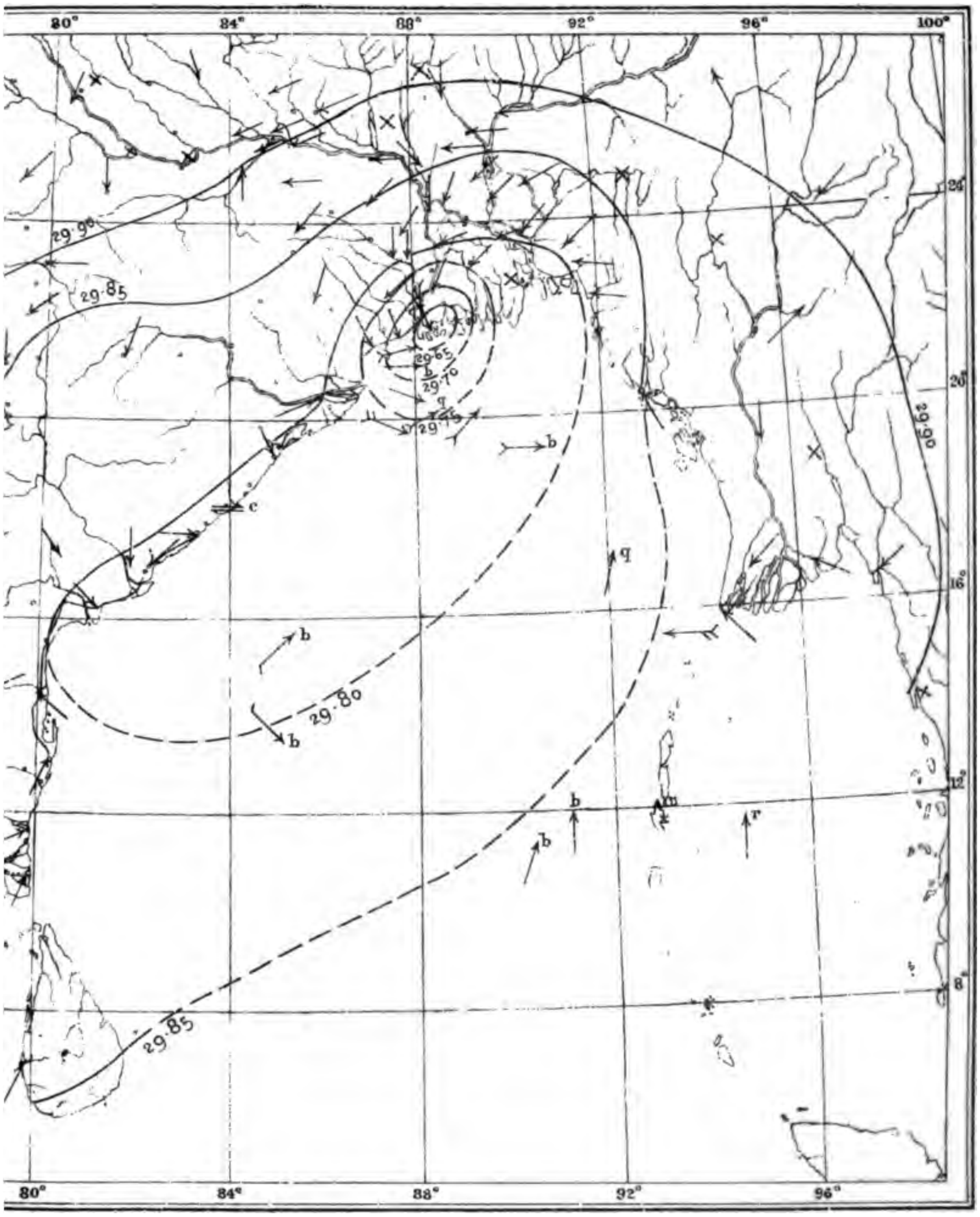

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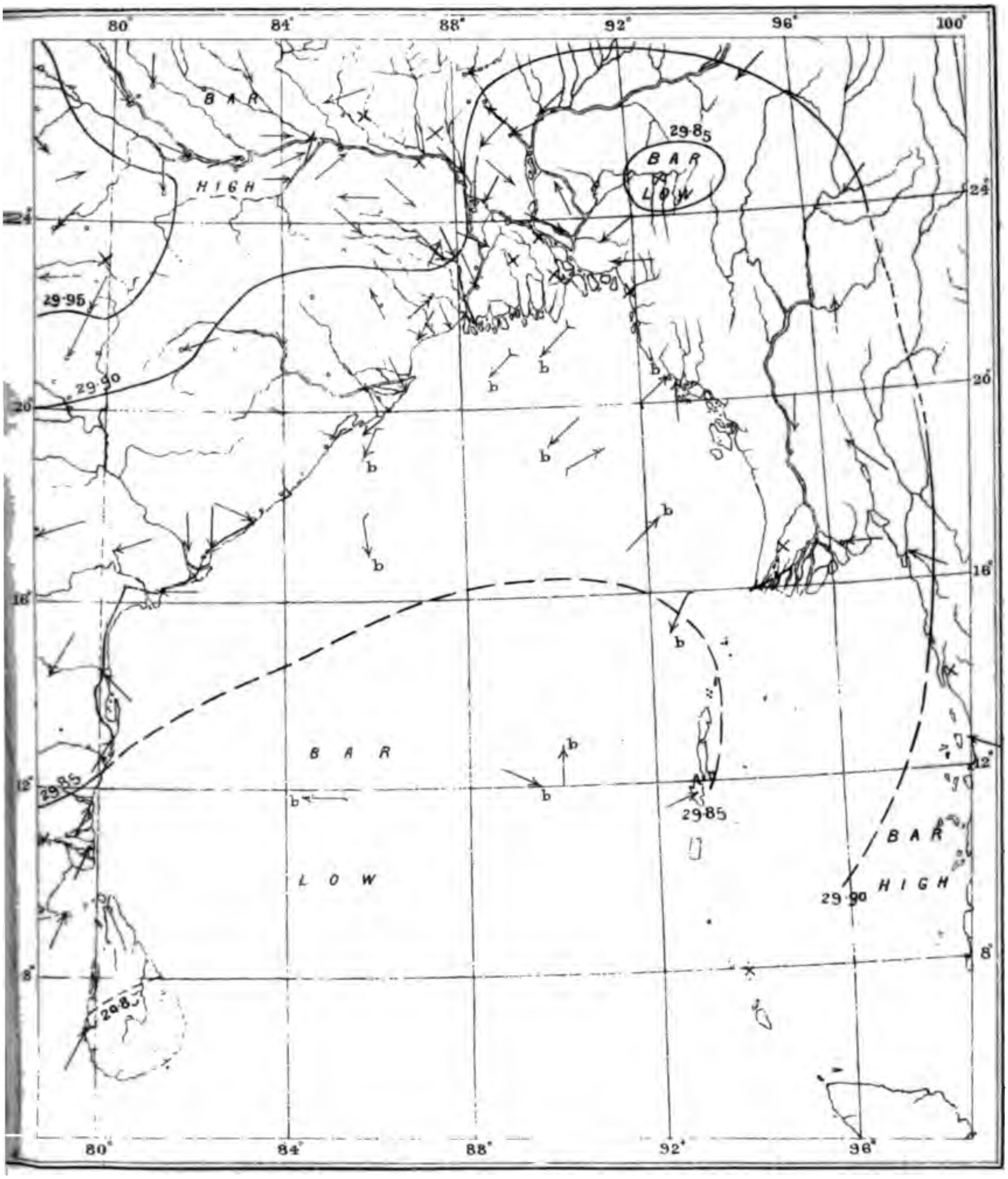

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MAP SHOWING PORTION OF THE MALAY PENINSULA CROSSED BY THE STROM OF 1st NOV. 1891.

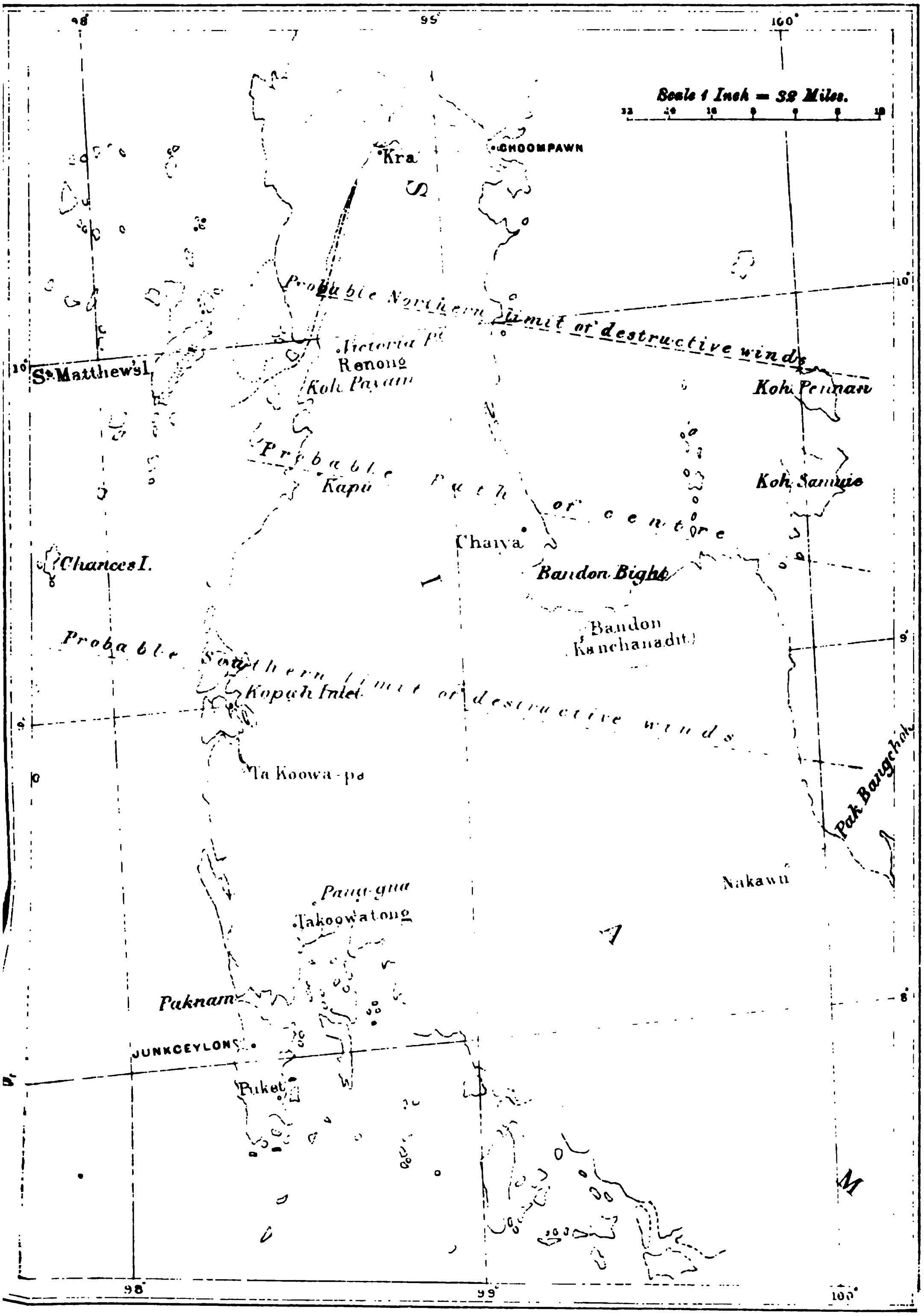

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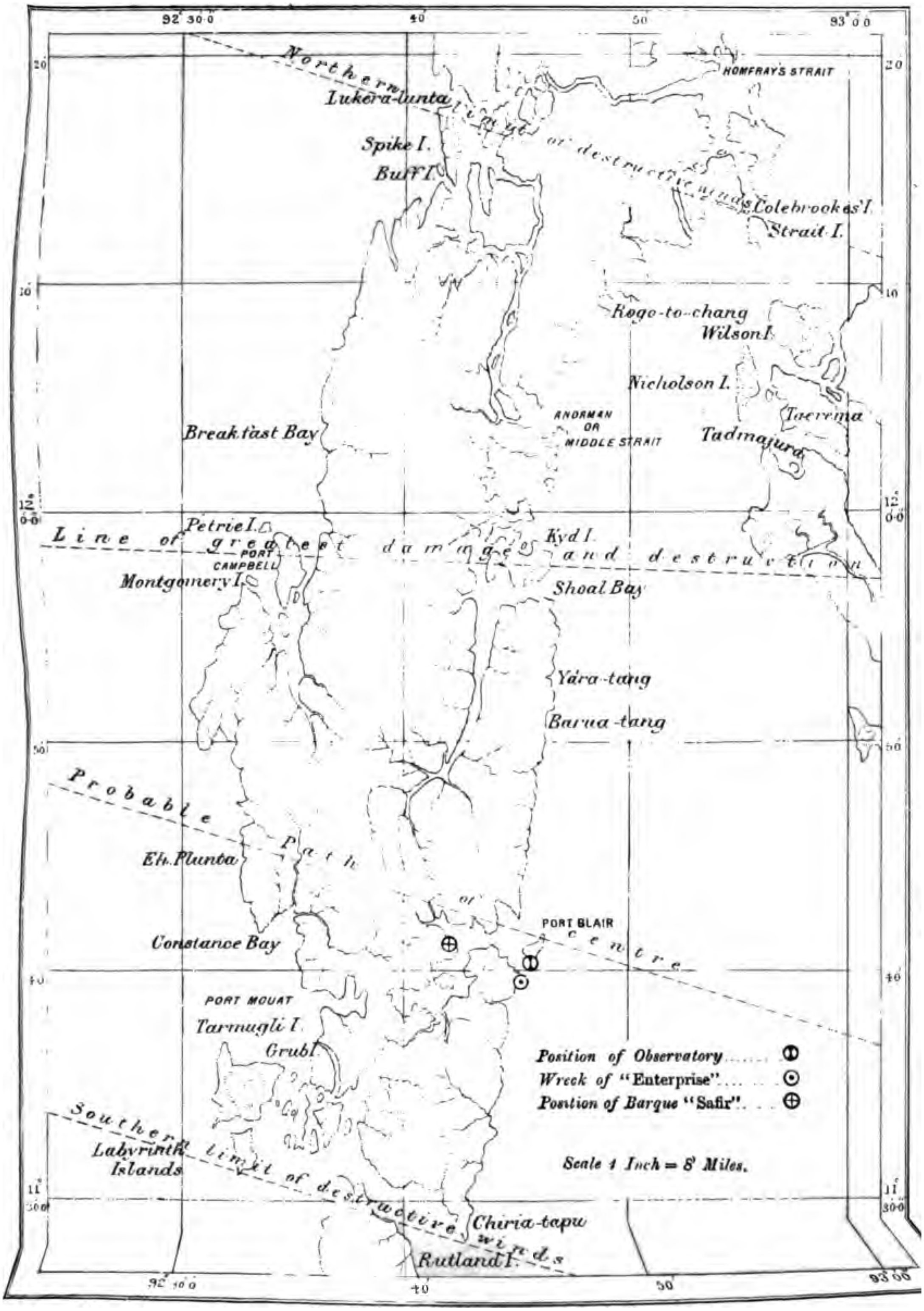
CHART OF SOUTH ANDAMAN ISLAND SHEWING TRACK OF THE STORM AND LIMIT OF DESTRUCTIVE WINDS, 2nd NOV. 1891.



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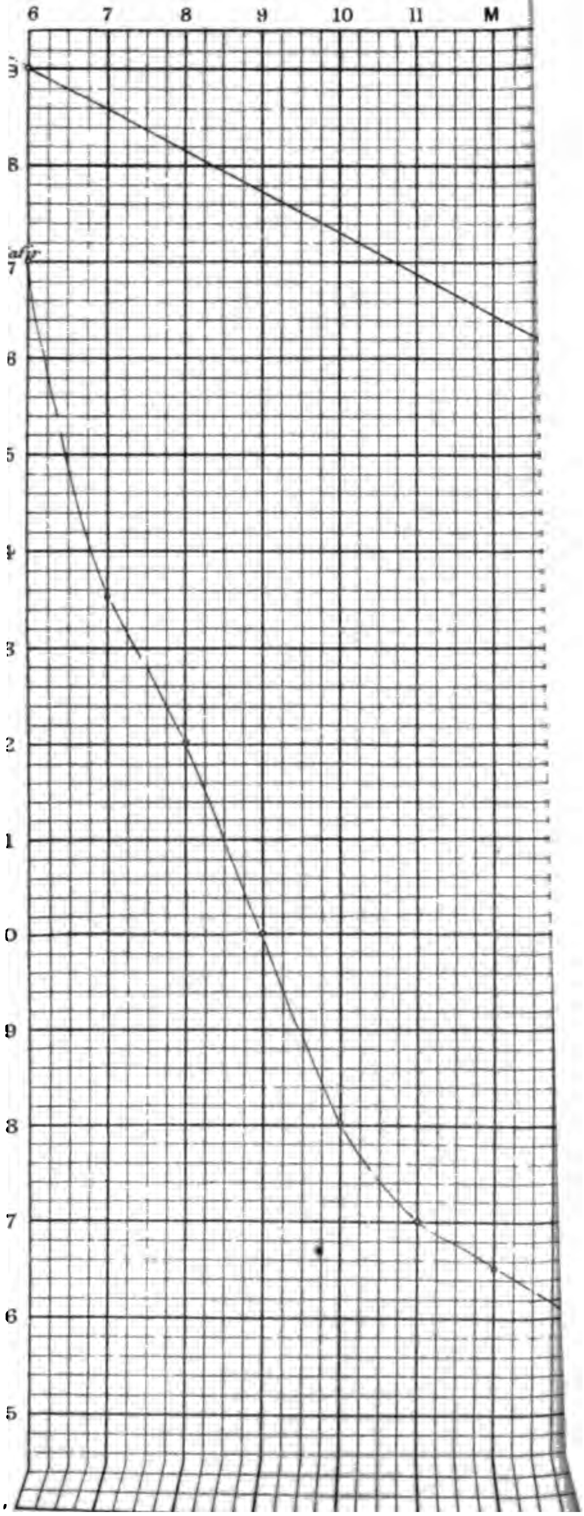

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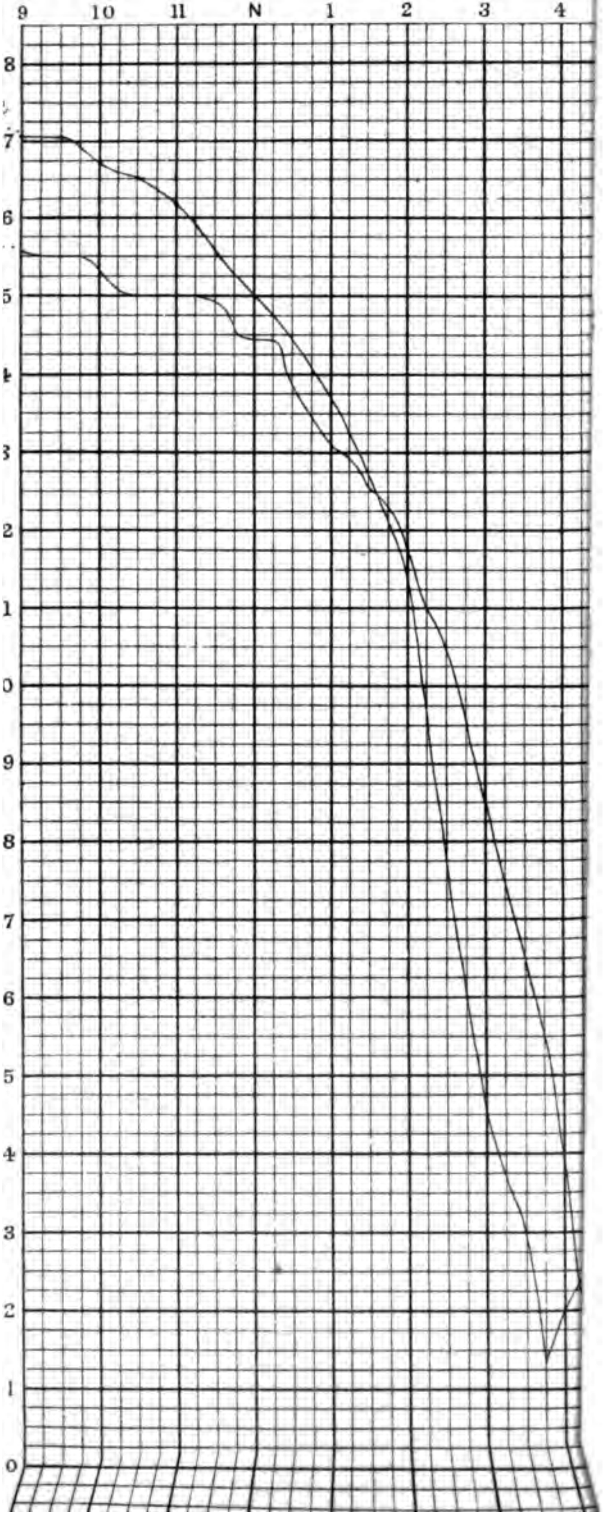

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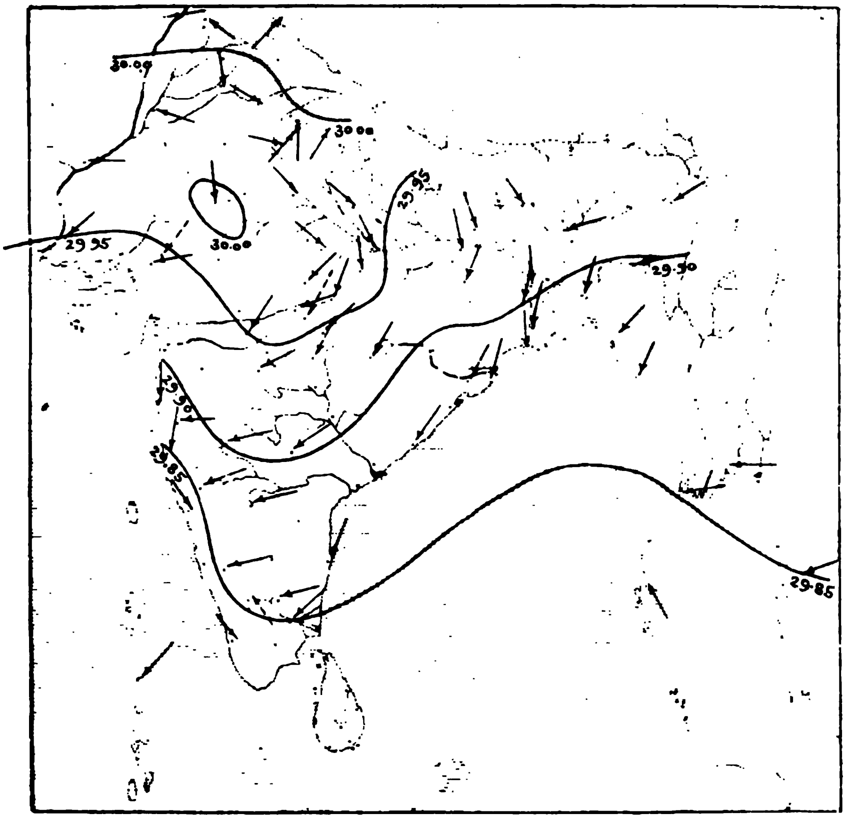
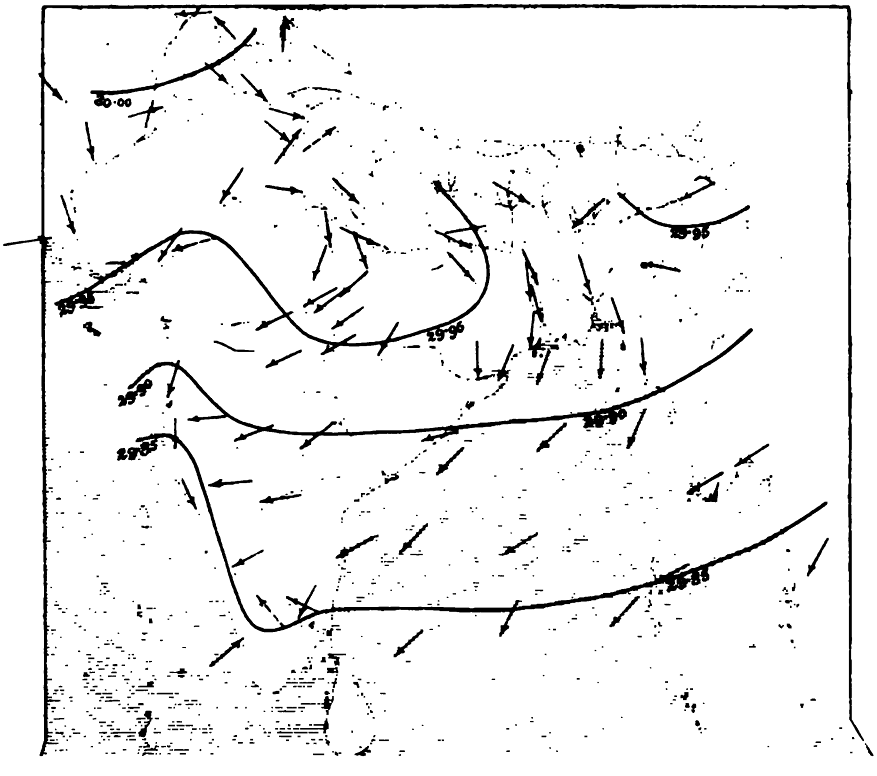
MEAN DISTRIBUTION OF PRESSURE AND WIND DIRECTION JN NOV. 1891.



NORMAL MEAN DISTRIBUTION OF PRESSURE AND WIND JN NOV.



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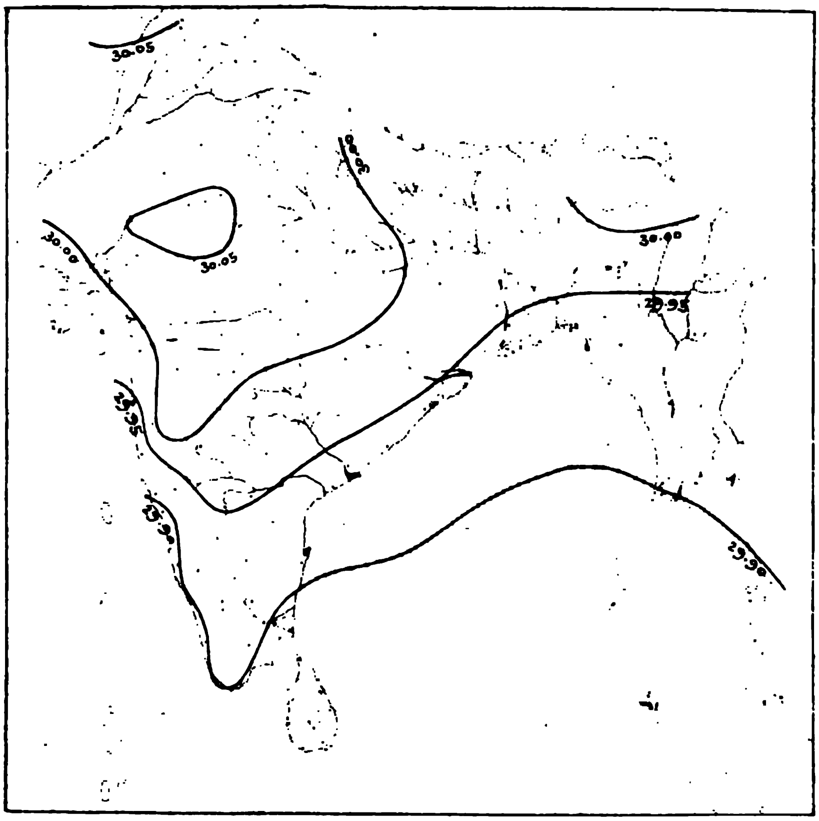
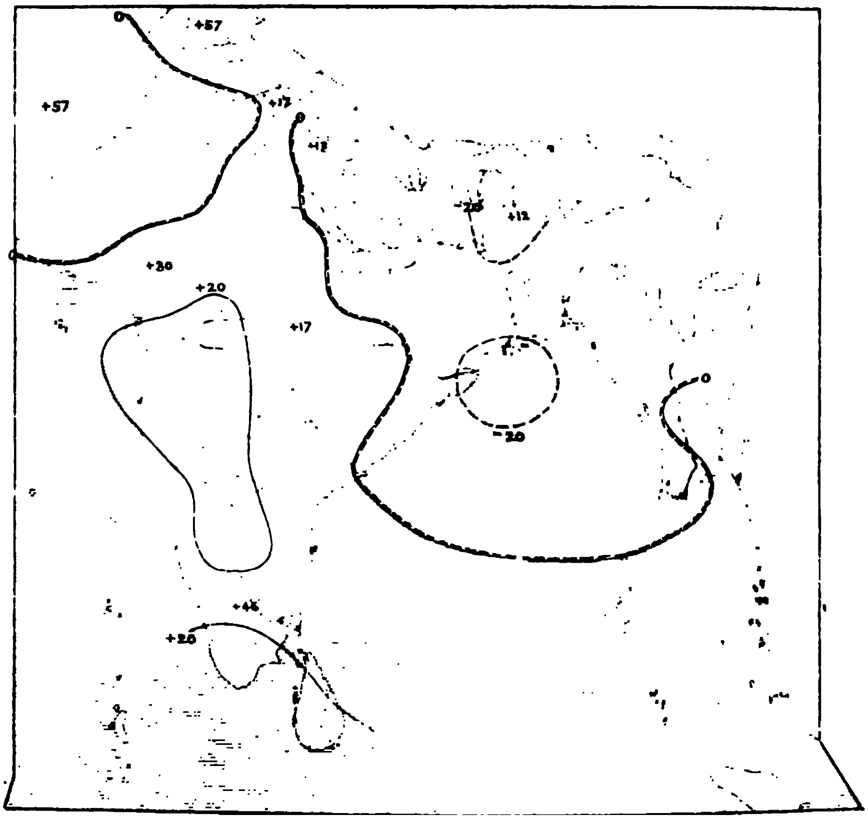
MEAN 8 a. m. DISTRIBUTION OF PRESSURE IN NOVEMBER 1891.



ARIATION OF MEAN 8 a. m. PRESSURE FROM NORMAL IN NOV.- 18



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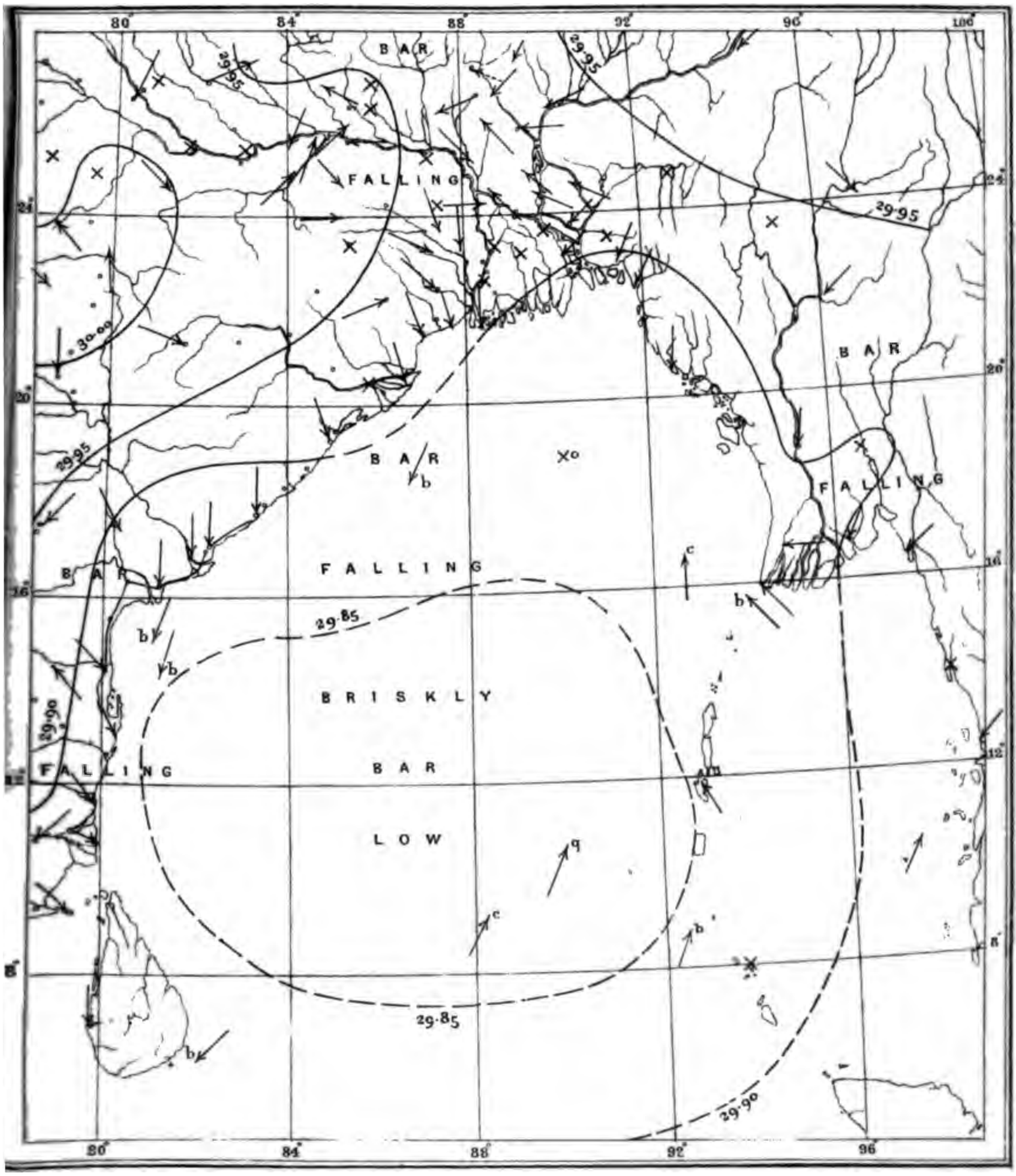
ASTOR [illegible] AND
TILDEN [illegible]

WEATHER CHART OF THE BAY OF BENGAL, 19th NOV. 1891.



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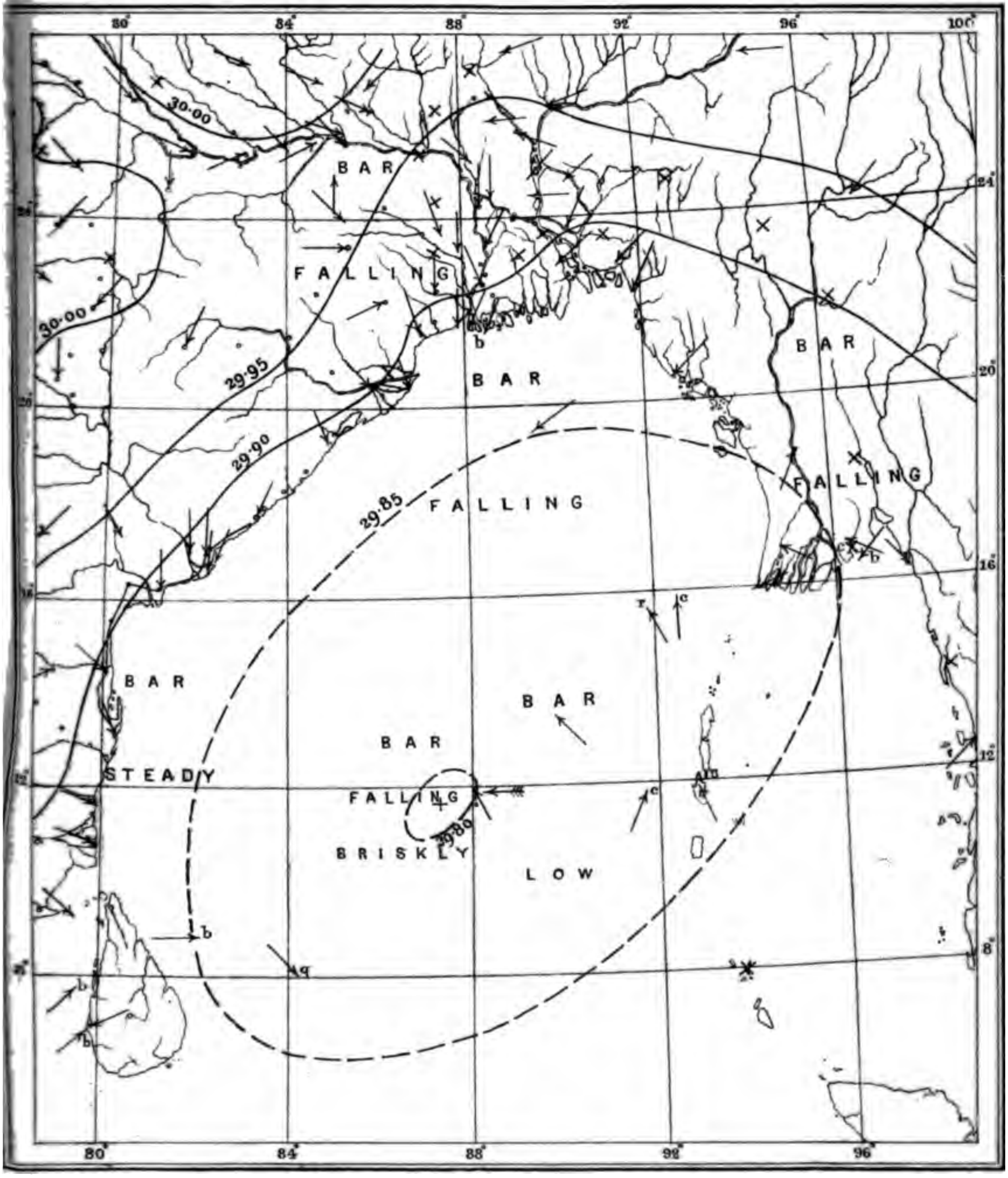
WEATHER CHART OF THE BAY OF BENGAL, 20th NOV. 1891.



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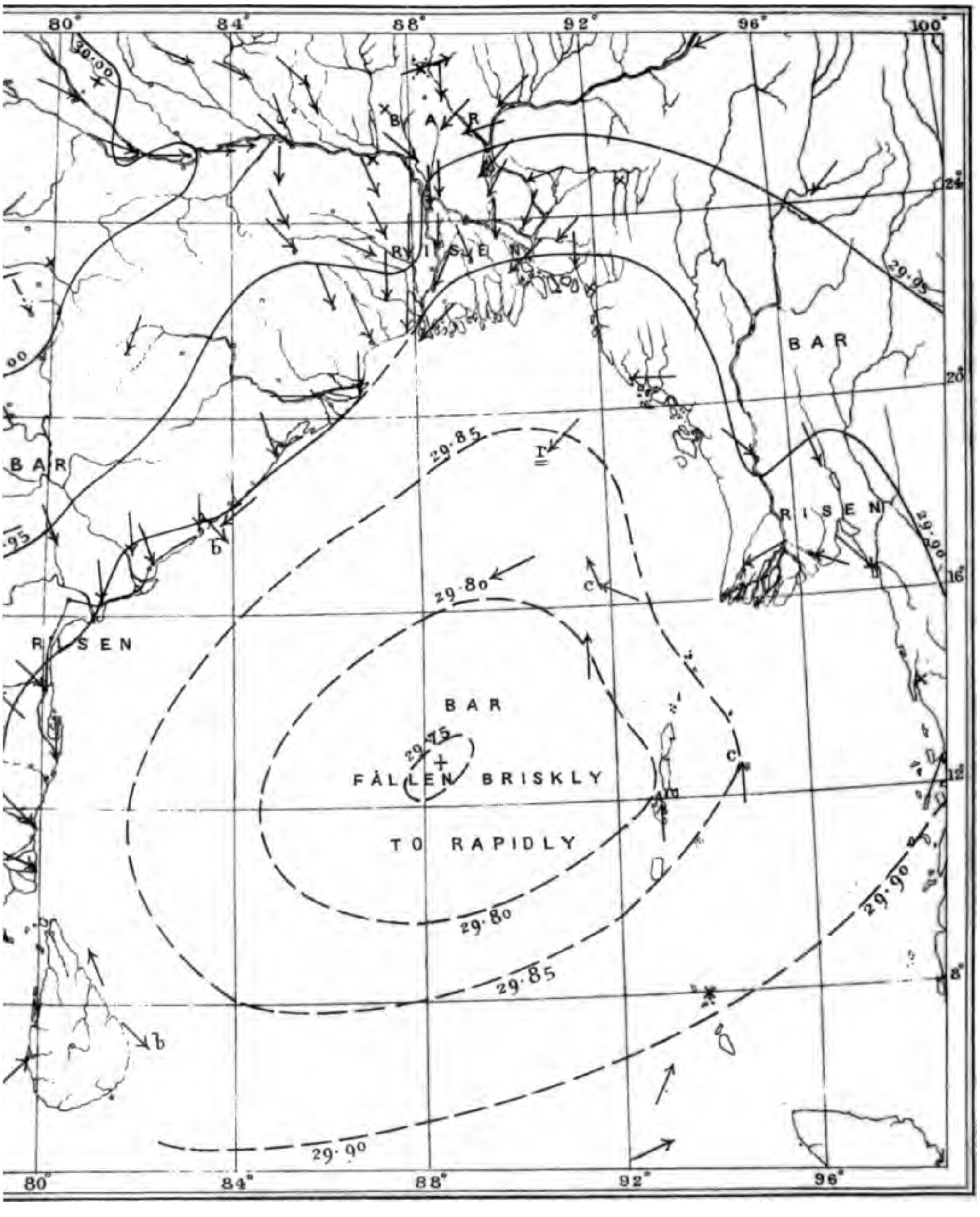
WEATHER CHART OF THE BAY OF BENGAL, 21st NOV. 1891.



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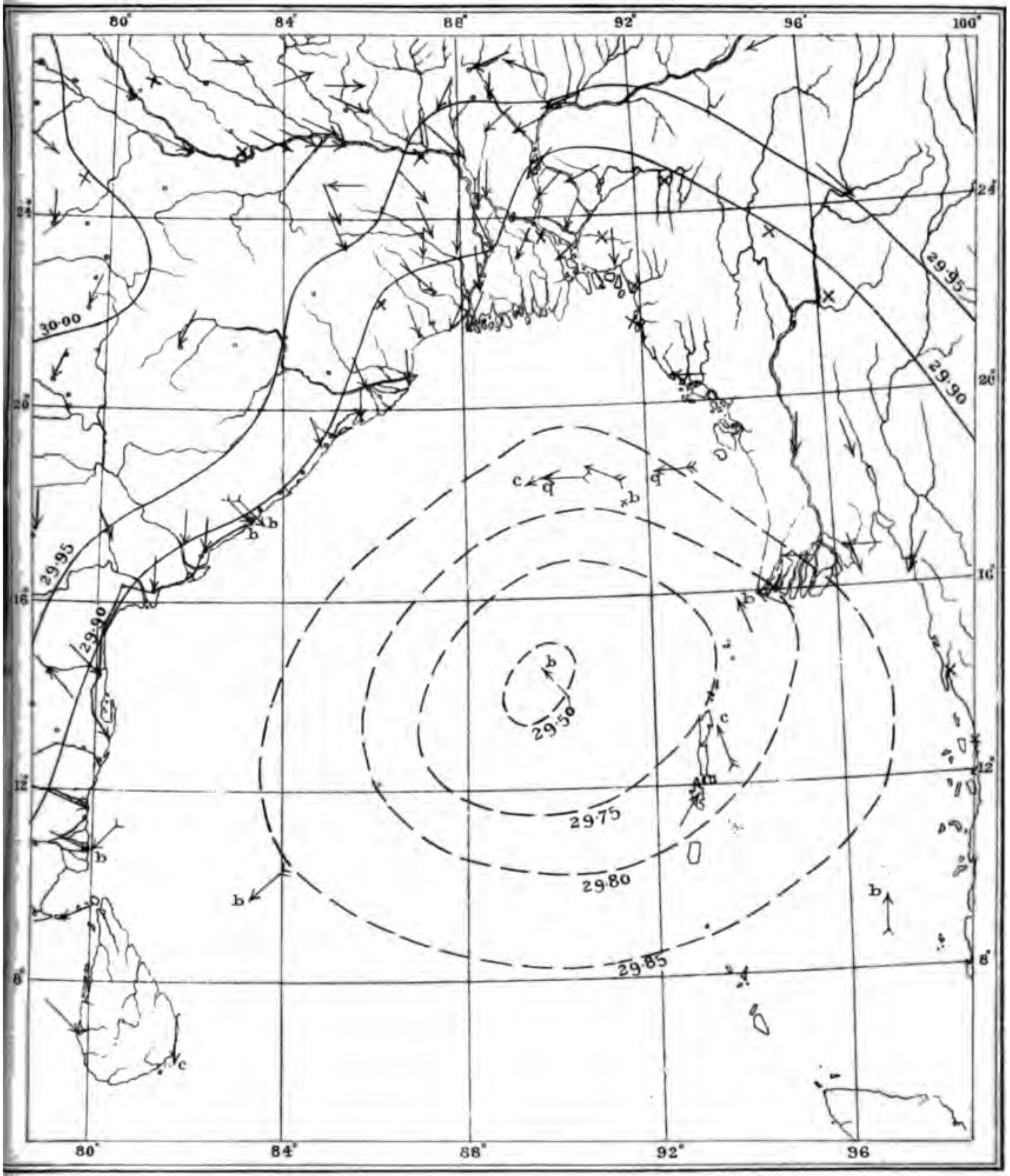
WEATHER CHART OF THE BAY OF BENGAL, 22nd NOV. 1891.



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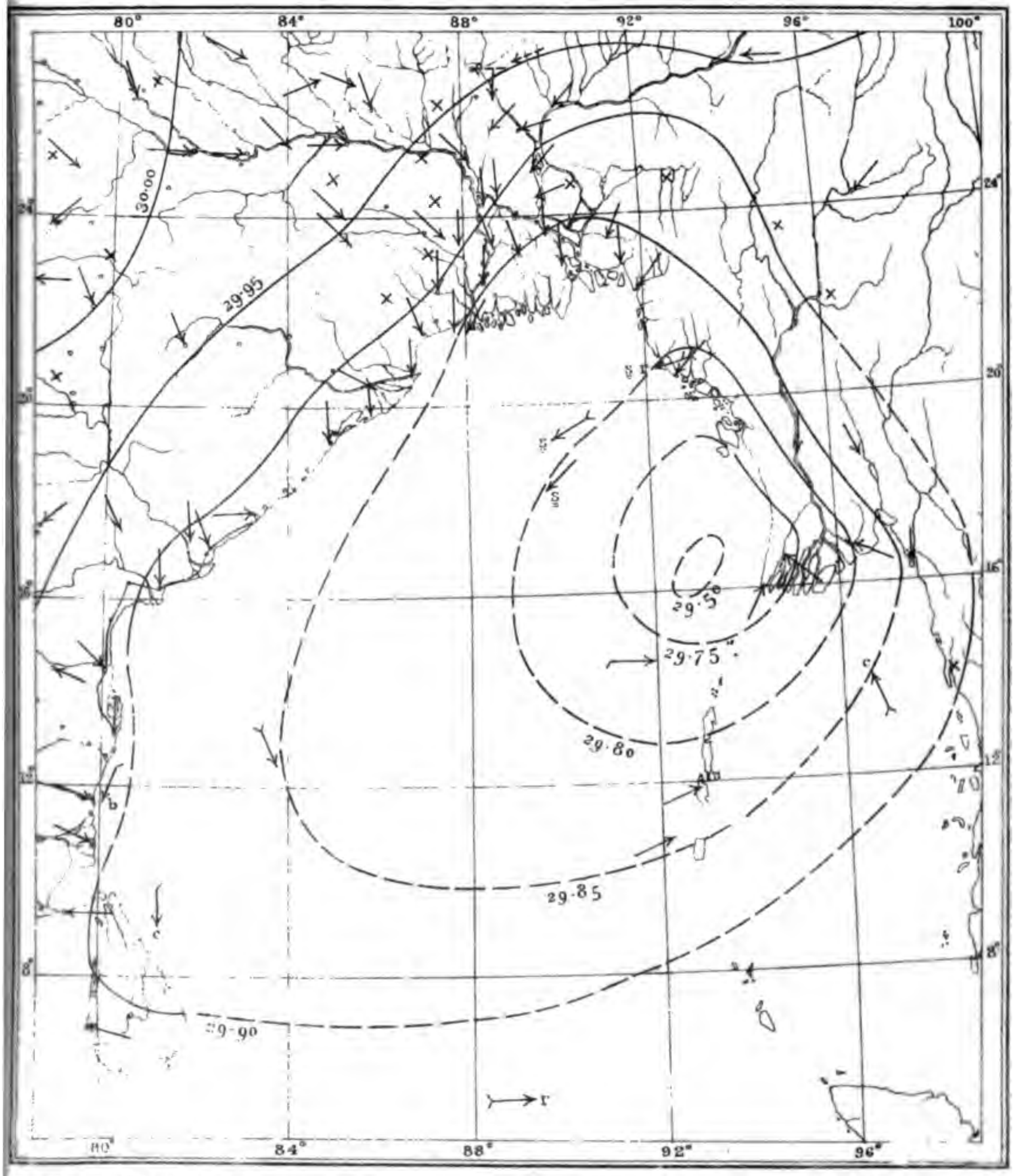
WEATHER CHART OF THE BAY OF BENGAL, 23rd NOV. 1891.



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